



Biological Assessment Report

Strother Creek Iron and Reynolds Counties, Missouri

Fall 2020 – Spring 2021

Prepared for:
Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

Prepared by:
Missouri Department of Natural Resources
Division of Environmental Quality
Environmental Services Program
Water Quality Monitoring Section

Table of Contents

Section	Page
1.0 Introduction.....	1
2.0 Study Area	2
2.1 MoRAP Aquatic Ecological Classification	2
2.1.1 Ecological Drainage Unit.....	2
2.1.2 Aquatic Ecological Systems	3
2.1.3 Valley Segment Types	4
2.2 Station Locations and Descriptions	4
3.0 Objectives	4
3.1 Null Hypotheses.....	5
4.0 Methods.....	5
4.1 Land Use Description	5
4.2 Stream Habitat Assessment Project Procedure	6
4.3 Macroinvertebrate Sampling and Analysis.....	6
4.4 Physicochemical Water Sampling and Analysis.....	7
4.5 Discharge	7
4.6 Fine Sediment Collection and Chemical Analysis.....	8
4.7 Quality Assurance/Quality Control (QA/QC)	8
4.7.1 Field Meters	8
4.7.2 Biological Samples	8
4.7.3 Biological Data Entry	8
4.7.4 Duplicate Sample Collection	8
5.0 Results.....	9
5.1 Land Use	9
5.2 Stream Habitat Assessment.....	11
5.3 Biological Assessment and Macroinvertebrate Community Analysis... 12	
5.3.1 Macroinvertebrate Community Composition and Analysis	14
5.3.1.1 Fall 2020 Sampling Season.....	14
5.3.1.2 Spring 2021 Sampling Season	18
5.4 Physicochemical Water Parameters.....	21
5.5 Chemical Analysis of Fine Sediments	24
5.6 Quality Assurance/Quality Control (QA/QC)	25
6.0 Discussion	26
6.1 Land Use	26
6.2 Stream Habitat Assessment.....	26
6.3 Biological Assessment and Macroinvertebrate Community Analyses.. 26	
6.4 Physicochemical Water Parameters.....	27
6.5 Chemical Analysis of Fine Sediment.....	28
7.0 Summary	28
8.0 Conclusion	29
9.0 Literature Cited	30

	Page
Tables	
Table 1	Percent land use in the Strother Creek and BIOREF stream watersheds and the Ozark/Black Current EDU 10
Table 2	Strother Creek and Blair Creek habitat values and scores 12
Table 3	Fall 2020 metric values and MSCI scores for Strother Creek using Ozark/Black/Current biological criteria 13
Table 4	Spring 2021 metric values and MSCI scores for Strother Creek using Ozark/Black/Current biological criteria 13
Table 5	Percent EPTT, Dominant Family, and Dominant Taxa at the Strother Study Stream Stations and the Ozark/Black/Current EDU Biological Criteria Reference Samples, Fall 2020 15
Table 6	Percent EPTT, Dominant Family, and Dominant Taxa at the Strother Study Stream Stations and the Ozark/Black/Current EDU Biological Criteria Reference Samples, Spring 2021 19
Table 7	Physicochemical Variables for Surface Water Samples at Strother Creek Stations, Fall 2020 22
Table 8	Physicochemical Variables for Surface Water Samples at Strother Creek Stations, Spring 2021 24
Table 9	Results from fine sediment analysis for Strother and Neals creeks 25

Figures

Figure 1	Strother Creek sampling locations 2
Figure 2	Location of Strother Creek and BIOREF streams in the Ozark/Black/Current EDU 3
Figure 3	Land uses within Strother Creek watershed 6
Figure 4	Fall 2020 percent of taxa by biotic index range 16
Figure 5	Fall 2020 percent of taxa by functional feeding group 17
Figure 6	Spring 2021 percent of taxa by biotic index range 20
Figure 7	Spring 2021 percent of taxa by functional feeding group 21

Attachments

Appendix A	Strother Creek Bioassessment Study Macroinvertebrate Bench Sheets
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1.0 Introduction

At the request of the Missouri Department of Natural Resources (**MoDNR**) Water Protection Program (**WPP**), the Environmental Services Program (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a macroinvertebrate biological assessment and habitat study of Strother Creek. WQMS staff collected macroinvertebrate, water quality, and sediment samples from four Strother Creek stations in Iron and Reynolds counties, Missouri. Macroinvertebrate and water quality samples and assessment of stream habitat occurred during the fall 2020 sampling season on September 29-30, 2020. Spring 2021 macroinvertebrate and water quality sampling occurred on March 22, 2021. Sediment samples were collected on May 5, 2021.

Strother Creek flows eastward along the boundary of Iron and Reynolds counties and is a substantial tributary to Middle Fork of the Black River (Figure 1). Major tributaries to Strother Creek include Neals Creek and Little Creek. Strother Creek is a classified stream with water body identification number (**WBID**) 2751 from its confluence with Middle Fork of the Black River upstream to its confluence with Little Creek. Upstream of the Little Creek confluence, the Strother Creek WBID is 3965. The Missouri Water Quality Standards (**WQS**, MoDNR 2018g) classify Strother Creek from its mouth to the Little Creek confluence as a class “P” stream. The stream reach upstream of the Little Creek confluence is classified as a class “C” stream. Streams classified as “P” are permanent streams that maintain flow even in drought periods, and streams classified as “C” may cease flow in dry periods but maintain permanent pools that support aquatic life.

Strother Creek has the following designated uses: irrigation, livestock and wildlife protection; protection of warm water habitat and human health protection; category “B” whole body contact recreation; and secondary contact recreation. Category “B” whole body contact applies to waters that are designated for whole body contact recreation but are not considered public use areas. The downstream portion of the stream (WBID 2751) also has protection of cool water habitat as a designated use.

The headwaters of Strother Creek contain the Buick Mine tailings pond (also known as Amax Tailing Pond), which is a large impoundment used to store the ore processing wastes of lead, zinc, copper, and silver from the Buick Mine. There is also the Magmont Mine tailings pond located in the headwaters of Neals Creek. In addition to these metals mining operations, small sand and gravel mining operations are also located within the Strother Creek drainage. Due to metals pollution from the Buick Mine, portions of Strother Creek were placed on the 303(d) list of impaired waters from 2006-2014 (MoDNR 2016a). In 2018, Strother Creek was removed from the 303(d) list due to new data indicating water and sediment metal concentrations met water quality standards after restoration action was taken (MoDNR 2018a). Continued monitoring of Strother Creek is necessary to ensure metals concentrations comply with water quality standards and the stream is capable of supporting aquatic life.

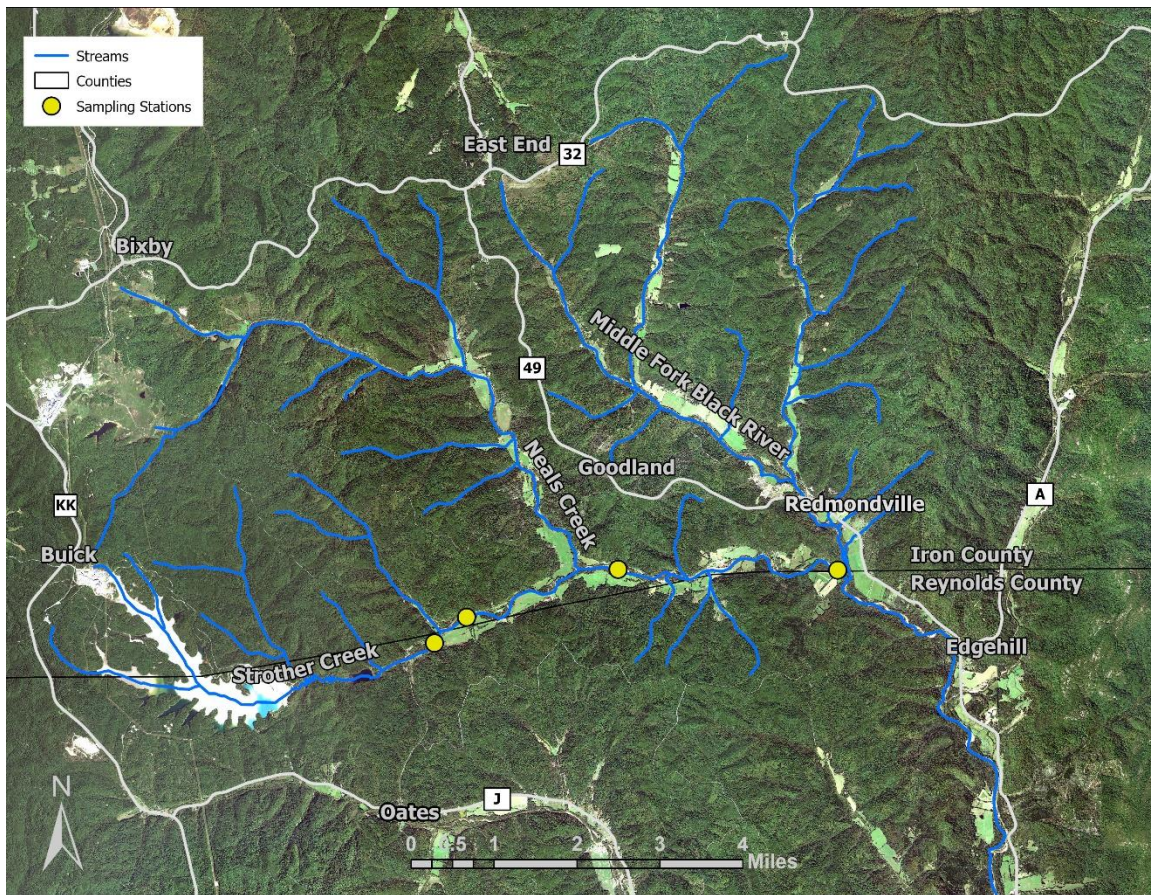


Figure 1. Strother Creek sampling locations

2.0 Study Area

2.1 MoRAP Aquatic Ecological Classification

The aquatic ecological classification developed by the Missouri Resource Assessment Partnership (**MoRAP**) divides the aquatic resources of Missouri into distinct regions. It has seven levels of classification starting at large regions then dividing them into smaller sub-regions (Sowa et al. 2004). The following are the seven levels of classification in hierarchical order: zone, subzone, region, aquatic sub-regions, Ecological Drainage Unit (**EDU**), Aquatic Ecological Systems (**AES**), and Valley Segment Type (**VST**). The levels of classification are based on biology, zoogeography, taxonomic composition, geology, soils, and groundwater connection. Some levels of the hierarchical system use geology and soils to classify, whereas other levels use biology and taxonomic composition of aquatic communities.

2.1.1 Ecological Drainage Unit

The EDU is level five of the classification hierarchy and is based on geographical variation of the taxonomic composition of the level four sub-regions. An EDU is a region in which aquatic biological communities and habitat conditions can be expected to be similar. Strother Creek is located in the Ozark/Black/Current EDU (Figure 2).

Macroinvertebrate samples for all Strother Creek sites were compared to Ozark/Black/Current EDU wadeable/perennial biological criteria reference (**BIOREF**) streams (MoDNR 2002). The following streams were used to calculate BIORREF stream biological criteria: Big Creek, Blair Creek, East Fork Black River, Jacks Fork, Little Black River, Sinking Creek (Shannon County), and Sinking Creek (Reynolds County). These streams and the data generated from them will be referred to as BIORREF throughout the report.

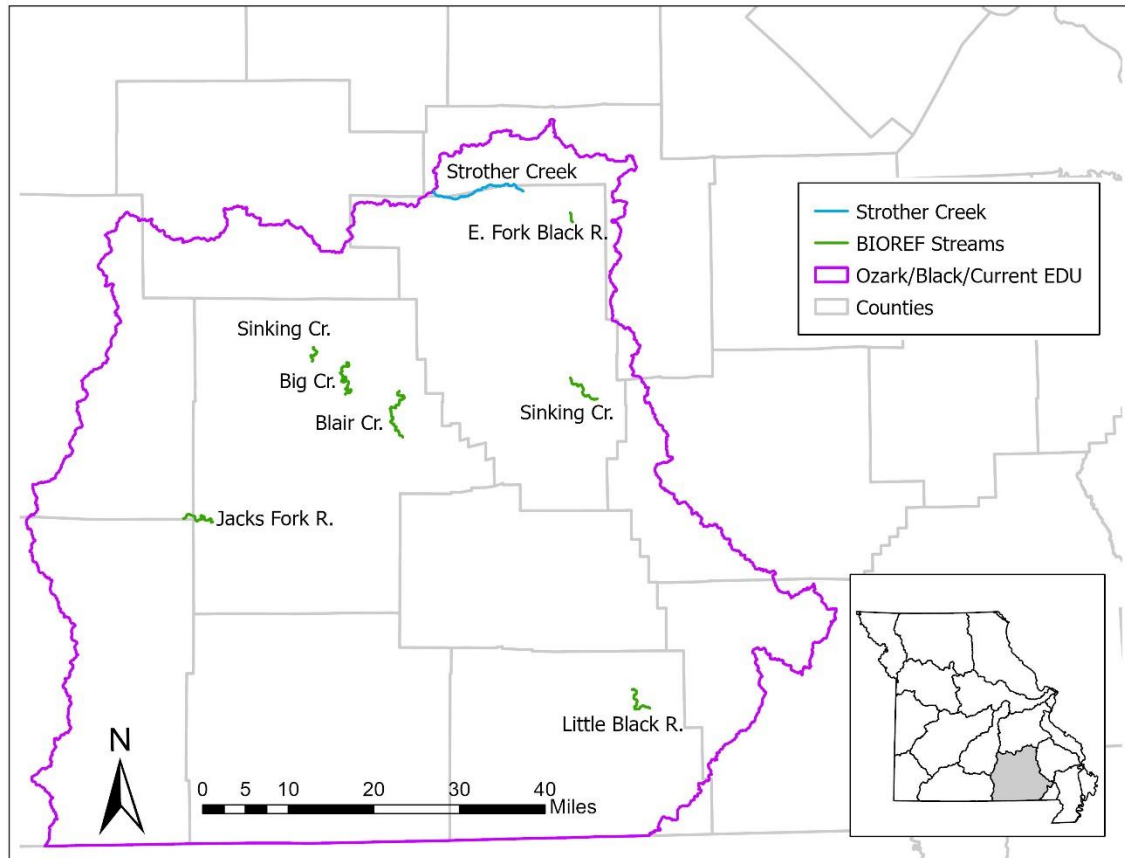


Figure 2. Location of Strother Creek and BIORREF streams in the Ozark/Black/Current EDU

2.1.2 Aquatic Ecological Systems

AES is level six of the classification hierarchy. Aquatic systems are classified based on geology, soils, landform, and groundwater influence. Strother Creek is located in the Little St. Francis River AES-Type (Sowa and Diamond 2006). Local relief is typically high, from 15 to about 150 meters. The Little St. Francis River AES-Type is characterized by impervious Precambrian igneous granite that is intermixed with rhyolite and other volcanic rock. The resistant igneous rock often forms shut-ins within stream channels. The soils in this AES-Type are moderately deep and acidic with a texture consisting of cherty, silty loams, and stony soils with moderate to slow infiltration rates

(Sowa and Diamond 2006). Streams in this AES-Type typically have good water clarity with little suspended sediment, but they carry bed loads of gravel and sand.

2.1.3 Valley Segment Types

VST is level seven of the classification hierarchy. Stream segments in the Geographical Information System (GIS) stream network layer are classified using a five-digit code. The five-digit VST code is based on temperature regime, stream size, flow regime, geology, and relative gradient. The two most upstream Strother Creek stations (3965_0.1 and 2751_5.5) have a VST code of 22123. The two downstream stations (3965_0.1 and 3965_0.1 have a VST code of 22122. All five stations are classified as having a warm water temperature regime, stream size classification of creek, permanent flow regime, and dolomite/limestone geology. The difference in VST codes relates to relative gradient. The two most upstream stations are classified as high gradient stream segments and the two most downstream stations are medium gradient stream segments.

2.2 Station Locations and Descriptions

Stations are labeled by their WBID and river mile (WBID_mile). The following are location descriptions for the four Strother Creek bioassessment stations sampled in fall 2020 and spring 2021. Stations are listed from upstream to downstream. All stations are in Universal Transverse Mercator (UTM) zone 15.

3965_0.1 – Legal description: NW1/4 Sec. 04, T. 33 N., R. 01 W. UTM coordinates were 672277 Easting, 4162413 Northing. The station is located 0.1 miles upstream of the Little Creek confluence in Reynolds County.

2751_5.5 – Legal description: SE1/4 Sec. 33, T. 34 N., R. 01 W. UTM coordinates were 672900 Easting, 4162908 Northing. This station is located 0.25 miles downstream of the Little Creek confluence south of County Road 69 in Iron County.

2751_3.3 – Legal description: SE1/4 Sec. 35, T. 34 N., R. 01 W. UTM coordinates were 675838 Easting, 4163841 Northing. This station is located 0.5 miles downstream of the Neals Creek confluence south of County Road 66 in Iron County.

2751_0.1 – Legal description: SW1/4 Sec. 32, T. 34 N., R. 01 E. UTM coordinates were 680100 Easting, 4163827 Northing. This station is located 0.1 miles upstream of the Middle Fork Black River confluence in Iron County.

3.0 Objectives

The objectives of this study were to evaluate stream habitat quality, water chemistry, fine sediment chemistry, and the macroinvertebrate community to determine if Strother Creek is supporting of aquatic life and meeting water quality standards. The macroinvertebrate community and instream habitat were compared longitudinally among the four Strother Creek stations and were also compared with BIOREF stream data from the Ozark/Black/Current EDU. Water quality and nutrient parameters were compared among the Strother Creek study stations, Missouri's WQS (MoDNR 2018g), and the U.S.

Environmental Protection Agency's (EPA) ambient water quality criteria recommendations for nutrients (U.S. EPA 2000).

3.1 Null Hypotheses

- 1) Stream habitat assessment scores of Strother Creek will be similar to a representative BIOREF stream (Blair Creek).
- 2) The macroinvertebrate community will be similar among stations located longitudinally along Strother Creek.
- 3) The macroinvertebrate community in Strother Creek will be similar to the macroinvertebrate community of BIOREF streams in the Ozark/Black/Current EDU.
- 4) Physicochemical water quality of Strother Creek will meet Missouri's WQS and EPA's recommended values.
- 5) Sediment metals concentrations will be below probable effects concentrations (PECs).

4.0 Methods

Macroinvertebrate and water quality samples were collected in fall 2020 and spring 2021 by the WQMS's Aquatic Bioassessment Unit. Methods for stream habitat assessments, biological assessments, and physicochemical water quality and fine sediment collection are included in this section. All samples were handled according to the appropriate MoDNR ESP Standard Operating Procedures (SOP) and Project Procedures (PP).

Macroinvertebrate and water quality samples were collected and stream habitat assessments took place in the fall 2020 sampling season on September 29-30, 2020. Spring 2021 sampling occurred on March 22, 2021. Strother Creek sediment samples were collected on May 5, 2021. Results of two sediment samples collected in 2021 (March 16 and December 7) on Neals Creek for the Sediment Monitoring Program by Dave Gullic of WQMS are included in this report for analysis.

4.1 Land Use Description

Figure 3 displays the land use within the Strother Creek watershed. Percent land use type was determined for Strother Creek and BIOREF watersheds using a 2019 layer from the National Land Cover Database (United States Geological Survey [USGS] 2019) and calculated using the hydrology toolbox in ArcGIS® 10.7.1 software by Esri ArcGIS®.

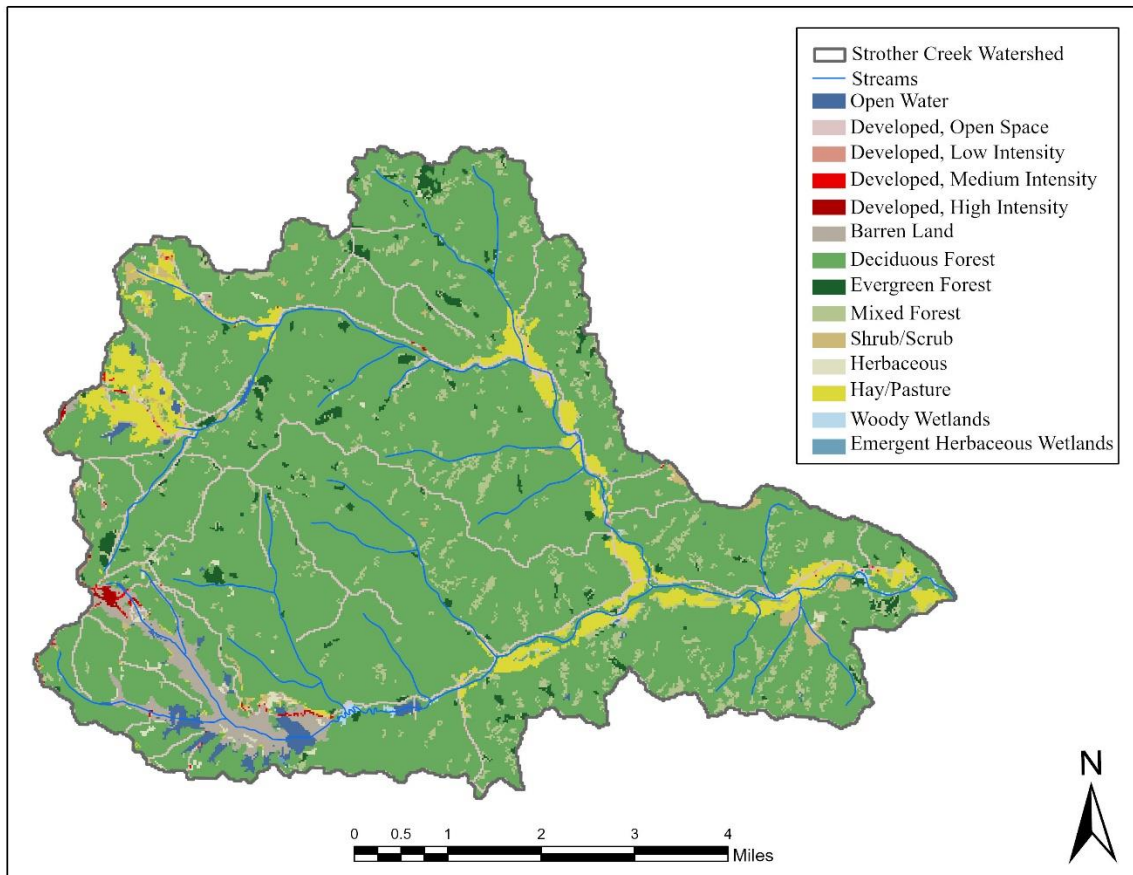


Figure 3. Land Uses of the Strother Creek Watershed

4.2 Stream Habitat Assessment Project Procedure

Standardized assessment procedures were followed as described for riffle/pool prevalent streams in the Stream Habitat Assessment Project Procedure (**SHAPP**, MoDNR 2019e). According to the SHAPP, an aquatic community is influenced by the quality of the stream habitat. Stream habitat quality was scored for each station, and the scores were compared with a BIOREF stream reach SHAPP score. If the SHAPP score at a test station is ≥ 75 percent of the BIOREF SHAPP score, the stream habitat at the test station is considered to be comparable to the BIOREF stream.

4.3 Macroinvertebrate Sampling and Analysis

Macroinvertebrate sampling was conducted according to the *Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure* (MoDNR 2019a). Strother Creek is considered a riffle/pool dominated system. The three standard habitats sampled at all locations were flowing water over coarse substrate (**CS**), non-flowing water over depositional substrate (**NF**), and submerged rootmat (**RM**). Macroinvertebrate samples were subsampled in the laboratory and identified to taxonomic levels as specified in MoDNR's *Taxonomic Levels for Macroinvertebrate Identifications SOP* (MoDNR 2021)

to develop biological metrics (MoDNR 2019a). Macroinvertebrate bench sheet data are included in Appendix A.

Strother Creek macroinvertebrate data were evaluated relative to BIOREF streams in the Ozark/Black/Current EDU. Biological criteria were calculated separately for the fall (mid-September through mid-October) and spring (mid-March through mid-April) index periods. The *Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure* (MoDNR 2019a) provides details on the calculation of metrics and scoring of the multi-metric Macroinvertebrate Stream Condition Index (**MSCI**). The four components of the MSCI are Taxa Richness (**TR**); Ephemeroptera, Plecoptera, and Trichoptera Taxa (**EPTT**); Biotic Index (**BI**); and the Shannon Diversity Index (**SDI**). An MSCI score of 16-20 is considered fully supporting, 10-14 partially supporting, and 4-8 is non-supporting of the protection of warm water aquatic habitat beneficial use designation as listed in the Missouri WQS (MoDNR 2018g). BI values for taxa are specified in MoDNR's *Taxonomic Levels for Macroinvertebrate Identifications SOP* (MoDNR 2021).

4.4 Physicochemical Water Sampling and Analysis

Physicochemical water samples were handled according to the appropriate MoDNR ESP SOPs. Results for physicochemical water parameters were examined by season and station by *in situ* field measurements or grab samples collected in accordance with the SOP MDNR-ESP-001, *Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations* (MoDNR 2020b). All samples were kept on ice during transport to ESP.

In situ field measurements included discharge (cubic feet per second-**cfs**, MoDNR 2015), dissolved oxygen (**DO**, mg/L, MoDNR 2019b), conductivity ($\mu\text{S}/\text{cm}$, MoDNR 2018f), pH (MoDNR 2018d), temperature ($^{\circ}\text{C}$, MoDNR 2018e), and turbidity (Nephelometric Turbidity Unit-**NTU**, MoDNR 2018c). The ESP Chemical Analysis Section conducted analyses for the following: nitrate plus nitrite-nitrogen, total nitrogen, total phosphorus, ammonia as N, sulfate, chloride, total suspended solids/non-filterable residue, dissolved calcium, dissolved magnesium, hardness as CaCO_3 , and dissolved metals (arsenic, barium, cadmium, copper, lead, nickel, and zinc). Physicochemical water parameters were compared among stations as well as with Missouri's WQS (MoDNR 2018g). Nutrient values were compared to EPA's recommended nutrient values for rivers and streams in nutrient ecoregion XI (U.S. EPA 2000). Interpretation of acceptable limits in the WQS may be dependent on a stream's classification and beneficial uses as designated in the WQS (MoDNR 2018g).

4.5 Discharge

Stream flow was measured using a SonTek/YSI FlowTracker[®] 2 Handheld Acoustic Doppler Velocimeter[®] at all stations in accordance with the SOP MDNR-ESP-113, *Flow Measurements in Open Channels* (MoDNR 2015).

4.6 Fine Sediment Collection and Chemical Analysis

Sediment samples were collected and analyzed for all four Strother Creek stations in accordance with SOP MDNR-ESP-011, *General Sampling Considerations for Chemical Analysis of Sediments* (MoDNR 2018b). Sediment samples were analyzed by the ESP Chemical Analysis Section for metals concentrations (arsenic, cadmium, chromium, copper, lead, nickel, and zinc). Percent moisture and total organic carbon (TOC) were analyzed by a contract laboratory. Metals concentrations of sediment samples were compared to probable effects concentration (PEC) values provided by MacDonald et al. 2000. A PEC is the level of a pollutant at which adverse effects to the biotic community are likely to occur (MacDonald et al. 2000). Individual metals were also examined using a Probable Effects Concentration Quotient (PEQ; MacDonald et al. 2000, 2009; Ingersoll et al. 2001, 2002, 2009; Besser et al. 2008, 2009). A PEQ is the total recoverable metal concentration divided by the PEC threshold for that metal (MacDonald et al. 2000). A PEQ greater than 1.0 may indicate an increased risk of toxicity due to the concentration of that metal (Ingersoll et al. 2001, Besser et al. 2009).

4.7 Quality Assurance/Quality Control (QA/QC)

4.7.1 Field Meters

All field meters used to collect water quality parameters were maintained in accordance with *Quality Control Procedures for Checking Water Quality Field Instruments* (MoDNR 2016b).

4.7.2 Biological Samples

Steps to assure accuracy of organism removal from sample debris were performed consistent with those methods found in the *Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure* document (MoDNR 2019a).

4.7.3 Biological Data Entry

All macroinvertebrate data were entered into the WQMS macroinvertebrate database consistent with *Quality Control Procedures for Data Processing* (MoDNR 2019d).

4.7.4 Duplicate Sample Collection

Duplicate samples are obtained from the same location at essentially the same time as the true sample following the same procedures in accordance with *Quality Assurance/Quality Control for Environmental Data Collection* (MoDNR 2019c). True samples and duplicate samples are analyzed for the same set of parameters. A duplicate is used to assess the precision associated with sampling methodology, sample heterogeneity, and analytical procedures (MoDNR 2019c).

Duplicate surface water samples were collected for physicochemical parameters at station 2751_0.1 in fall of 2020 and at station 3965_0.1 in spring of 2021. Duplicate samples are analyzed and reported independently.

Macroinvertebrate duplicate samples were assessed using the Quantitative Similarity Index for Taxa (QSIT). QSIT is a sampling protocol that expresses taxa similarity

between two samples as a percentage and can be used as a quality control measure. QSIT was calculated for the duplicate macroinvertebrate sample collected at Strother Creek station 2751_0.1 during the fall of 2020. Duplicate samples are expected to have a score of 70 percent or greater (Rabeni et al. 1999).

5.0 Results

5.1 Land Use

Table 1 provides a comparison between the land use within the Strother Creek watershed and the watersheds of BIOREF streams. Land use was generally similar across all watersheds and consisted mostly of forested land use type. Strother Creek and the BIOREF streams in Shannon and Reynolds counties (East Fork Black River, Sinking Creek, Big Creek, and Blair Creek) have a higher percent forest and lower percent of hay/pasture than the other BIOREF streams and the EDU as whole. The Strother Creek watershed has slightly more developed/barren land use and less hay/pasture land use than the EDU land use percentages.

Figure 3 illustrates where the different land use types are located within the Strother Creek watershed. There is a large area of barren land use where the Buick Mine tailings are located near the upstream end of Strother Creek. The downstream reaches of Strother Creek are bordered by hay/pasture land use. Overall, impervious surface in the Strother Creek watershed was less than 0.5 percent. However, among individual National Land Cover Database pixels, which have a 30-m resolution, impervious surface ranged from 0 to 100 percent. Greater than 95 percent of the watershed had no impervious surface, and only about 1 percent was greater than 10 percent. Most of the higher impervious surface values occurred in or near the Buick Mine tailings area. The land use categories “average percent impervious” and “impervious surface ≥ 10 percent” were higher than most BIOREF streams but were slightly lower than the Ozark/Black/Current EDU as whole.

Table 1. Percent land use in the Strother Creek and BIOREF stream watersheds and the Ozark/Black Current EDU

Land Use Type	Strother Creek	E. Fork Black R.	Sinking Cr. (Shannon Co.)	Big Creek	Blair Creek	Sinking Cr. (Reynolds Co.)	Jacks Fork	Little Black R.	EDU
Open Water	1.0	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.4
Average Percent Impervious Surface	0.46	0.16	0.20	0.27	0.09	0.25	0.28	0.33	0.5
Impervious Surface ≥ 10 Percent	1.03	0.42	0.65	0.76	0.25	0.69	0.91	1.18	1.40
Developed, Open Space	3.8	1.9	3.2	3.7	3.4	3.4	2.8	3.0	3.3
Developed, Low Intensity	0.3	0.1	0.2	0.2	<0.1	0.3	0.3	0.4	0.6
Developed, Medium Intensity	0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	0.2
Developed, High Intensity	0.1	<0.1	<0.1	<0.1	0.0	<0.1	<0.1	<0.1	<0.1
Barren Land	2.2	0.2	0.1	0.2	<0.1	0.4	0.1	<0.1	0.2
Deciduous Forest	79.4	86.2	84.4	84.7	89.2	79.7	67.5	64.1	65.4
Evergreen Forest	1.7	1.5	2.7	1.7	1.8	1.2	1.1	4.3	2.6
Mixed Forest	4.9	5.6	3.3	5.2	4.7	3.1	2.6	12.8	5.0
Shrub/Scrub	0.9	0.5	0.7	0.7	0.1	1.4	2.4	2.1	1.5
Herbaceous	0.5	0.4	0.7	0.1	0.1	0.7	0.9	2.0	1.2
Hay/Pasture	4.8	2.9	4.7	3.0	0.5	9.0	21.9	10.0	18.3
Cultivated Crops	--	--	--	--	--	--	--	<0.1	0.5
Wetland	0.2	0.2	0.1	0.1	<0.1	0.7	0.1	0.9	0.6

5.2 Stream Habitat Assessment

Habitat assessment scoring results are found in Table 2. If the study station SHAPP score is ≥ 75 percent of the BIOREF station score, the stations are considered to contain habitats comparable to the control station (MoDNR 2019e). Blair Creek, a BIOREF stream, was used to evaluate Strother Creek SHAPP scores. All Strother Creek stations scored ≥ 75 percent of the Blair Creek score. Based on SHAPP scores, it is inferred that the Strother Creek stations have habitats similar to the BIOREF streams and should, therefore, support a comparable biological community.

All Strother Creek stations had optimal epifaunal substrate scores. For most stations, benthic substrate consisted of a mix of gravel, pebble, and cobble sized substrate. Strother Creek stations 2751_5.5 and 2751_3.3 contained thick mats of filamentous green algae growing on the substrate. Sediment embeddedness was also optimal for all stations, except that station 2751_5.5 was suboptimal. The upper two Strother Creek stations were lacking in deep water habitat; however, the lower two stations contained all four velocity/depth regimes (slow/deep, slow/shallow, fast/deep, fast/shallow). Sediment deposition was suboptimal for all stations, with some new formation of gravel bars and deposition in pool habitat. Channel flow status was also suboptimal for all stations, with water filling between 75-99.9 percent of the channel. Although it is possible that channel alterations occurred in other reaches of Strother Creek (e.g. gravel mining, road construction), the stations sampled for this study had little to no channel alterations. The only notable alteration was a low water crossing upstream of station 3965_0.1. Riffle quality was optimal for all Strother Creek stations, with station 2751_0.1 having the lowest score. Bank stability was optimal to suboptimal for all stations except the marginal right bank of station 3965_0.1. Vegetative protection was marginal to poor for all Strother Creek stations. Riparian vegetative zone width was optimal to suboptimal for all stations except for the right bank of station 3965_0.1, which was poor. A lack of bank stability, vegetative protection, and riparian width was partially due to county roads 69 and 66 that ran along the length of Strother Creek. In addition to the county roads, there were also several power lines that intersected the stream's corridor. Maintenance of power line rights-of-way resulted in reduced vegetation and riparian corridor in several areas.

Blair Creek scored optimal for epifaunal substrate, sediment embeddedness, channel alterations, left bank stability, and riparian vegetative zone width. Blair Creek contained large amounts of gravel substrate with large gravel bars. The presence of gravel on the banks reduced bank vegetative protection, which was categorized as poor.

Table 2. Strother Creek and Blair Creek habitat values and scores

Stream Habitat Parameters	Strother Cr. 3965_0.1	Strother Cr. 2751_5.5	Strother Cr. 2751_3.3	Strother Cr. 2751_0.1	Blair Cr.
Habitat Assessment Date	9/29/20	9/29/20	9/29/20	9/30/20	9/30/20
Epifaunal Substrate/Avail. Cover	I(19)	I(19)	I(18)	I(17)	I(19)
Embeddedness	I(19)	II(15)	I(20)	I(19)	I(19)
Velocity/Depth Regime	II(15)	II(13)	I(17)	I(19)	III(10)
Sediment Deposition	II(14)	II(14)	II(12)	II(11)	II(14)
Channel Flow Status	II(15)	II(14)	II(13)	II(11)	III(10)
Channel Alteration	I(19)	I(17)	I(20)	I(19)	I(20)
Riffle Quality	I(18)	I(19)	I(17)	I(16)	II(14)
Left Bank Stability	I(9)	I(9)	I(9)	II(6)	I(9)
Right Bank Stability	III(4)	I(9)	II(6)	II(6)	III(5)
Left Bank Vegetative Protection	III(4)	IV(2)	IV(2)	IV(0)	IV(1)
Right Bank Vegetative Protection	IV(2)	IV(1)	IV(2)	IV(1)	IV(1)
Left Bank Riparian Zone Width	I(9)	II(6)	I(10)	I(10)	I(10)
Right Bank Riparian Zone Width	IV(2)	I(10)	I(10)	I(10)	I(9)
Total Habitat Score	149	148	156	145	141
Percent of Blair Creek Score	105.7	105.0	110.6	102.8	

Habitat parameter categories range from I to IV with category I = optimal, category II = suboptimal, category III = marginal, and category IV = poor. Habitat parameter scores are listed in parentheses and range from 0 to 20 except for bank stability, vegetative protection, and riparian zone categories, which range from 0 to 10.

5.3 Biological Assessment and Macroinvertebrate Community Analysis

During the fall 2020 and spring 2021 sampling seasons, the upstream two stations (3965_0.1 and 2751_5.5) attained partially supporting MSCI scores, and the two downstream stations (2751_3.3 and 2751_0.1) had fully supporting MSCI scores (Tables 3 and 4). Taxa richness, EPTT, and SDI were considerably lower in the two upstream stations than the two downstream stations in both seasons. The lowest MSCI score was at station 3965_0.1, which had scores of 12. Station 2751_5.5 had the lowest TR and SDI value of any station; however, it also had the lowest BI value during both sampling seasons. The two downstream stations' metric values were comparable to BIOREF streams, with MSCI scores of 18 or 20.

Table 3. Fall 2020 metric values and MSCI scores for Strother Creek using Ozark/Black/Current biological criteria

Stations	Sample Number	TR	EPTT	BI	SDI	MSCI	Support
Strother Creek. 3965_0.1	20125	79 ₍₃₎	11 ₍₃₎	5.4 ₍₃₎	3.18 ₍₃₎	12	P
Strother Creek 2751_5.5	20126	73 ₍₃₎	19 ₍₃₎	4.1 ₍₅₎	2.91 ₍₃₎	14	P
Strother Creek 2751_3.3	20127	95 ₍₅₎	32 ₍₅₎	4.6 ₍₅₎	3.47 ₍₅₎	20	F
Strother Creek 2751_0.1	20128	97 ₍₅₎	32 ₍₅₎	4.9 ₍₅₎	3.69 ₍₅₎	20	F
	20129	99 ₍₅₎	34 ₍₅₎	5.0 ₍₅₎	3.68 ₍₅₎	20	F
Metric Score=5		>85	>25	<5.2	>3.28	20-16	Full
Metric Score=3		85-43	25-13	5.2-7.6	3.28-1.64	14-10	Partial
Metric Score=1		<43	<13	>7.6	<1.64	8-4	Non

MSCI Scoring Table (in light gray) developed from BIOREF samples ($n = 23$). TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; (#) subscript indicates individual metric scores.

Table 4. Spring 2021 metric values and MSCI scores for Strother Creek using Ozark/Black/Current biological criteria

Stations	Sample Number	TR	EPTT	BI	SDI	MSCI	Support
Strother Cr. 3965_0.1	21068	78 ₍₃₎	18 ₍₃₎	5.4 ₍₃₎	3.00 ₍₃₎	12	P
Strother Cr. 2751_5.5	21069	68 ₍₃₎	17 ₍₃₎	4.3 ₍₅₎	3.03 ₍₃₎	14	P
Strother Cr. 2751_3.3	21070	88 ₍₃₎	32 ₍₅₎	4.4 ₍₅₎	3.60 ₍₅₎	18	F
Strother Cr. 2751_0.1	21071	103 ₍₅₎	33 ₍₅₎	4.6 ₍₅₎	3.61 ₍₅₎	20	F
Metric Score=5		>93	>31	<5.4	>3.37	20-16	Full
Metric Score=3		93-47	31-15	5.4-7.7	3.37-1.69	14-10	Partial
Metric Score=1		<47	<15	>7.7	<1.69	8-4	Non

MSCI Scoring Table (in light gray) developed from BIOREF samples ($n = 22$). TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; (#) subscript indicates individual metric scores.

5.3.1 Macroinvertebrate Community Composition and Analysis

5.3.1.1 Fall 2020 Sampling Season

Macroinvertebrate Community Composition

Table 5 compares the fall 2020 macroinvertebrate community among stations. Figure 4 depicts the percent taxa by BI ranges, and Figure 5 illustrates the percent of taxa by primary functional feeding group (FFG) for each fall sample.

Percent EPT taxa in Strother Creek ranged from 29.9 at station 2751_3.3 to 44.6 percent at station 3965_0.1 in fall of 2020 (Table 5). The most upstream sample (3965_0.1) had the greatest percent Ephemeroptera (mayflies); however, 93 percent of the mayflies collected at this station were made up of two taxa, *Tricorythodes* (family Leptohyphidae) and *Caenis latipennis* (family Caenidae). Mayflies at station 2751_5.5 also consisted mostly of *Tricorythodes*. In comparison, samples from the two downstream stations had higher percentages of *Isonychia bicolor* (family Isonychiidae), *Baetis* (family Baetidae), and heptageniid mayflies. Compared to BIOREF data, heptageniid mayflies were a little less abundant at the two most downstream stations but were diverse with *Stenonema bednariki*, *S. mediopunctatum*, *S. pulchellum*, and *Leucrocota* being present. In contrast, only one unidentified Heptageniidae specimen was found at station 3965_0.1, and one *Stenacron* specimen was found at station 2751_5.5.

Plecoptera (stoneflies) were found in low abundance at Strother Creek as well as BIOREF streams, but percentages were slightly lower in the Strother Creek samples. No Plecoptera taxa were collected at station 3965_0.1.

Percent Trichoptera (caddisflies) was higher among Strother Creek stations than BIOREF streams. *Cheumatopsyche* (family Hydropsychidae) was the most prevalent caddisfly at all stations except station 2751_3.3, which had a greater abundance of *Agapetus* (family Glossosomatidae).

Chironomids (non-biting midges) made up close to 25 percent of samples at the two upstream stations, which was much higher than the BIOREF streams and the downstream Strother Creek stations. Most of the chironomid abundance at the two upstream stations were made up of *Parachaetocladius*, *Tanytarsus*, and *Stempellinella*.

Other notable taxa collected in fall of 2020 were snails in the family Pleuroceridae and riffle beetles (Elmidae). *Elimia*, a pleurocerid snail, made up 26.7 percent of the station 2751_5.5 fall 2020 sample. Elmids *Stenelmis* and *Microcylloepus pusillus* were more common at the two upstream stations, and *Optioservus sandersoni* and *Dubiraphia* were more common at the two downstream stations.

Table 5. Percent EPTT, Dominant Family, and Dominant Taxa at the Strother Creek Study Stream Stations and the Ozark/Black/Current EDU Biological Criteria Reference Samples, Fall 2020

Variable-Station	BIOREF Samples	Strother Creek 3965_0.1	Strother Creek 2751_5.5	Strother Creek 2751_3.3	Strother Creek 2751_0.1	
Sample Number		20125	20126	20127	20128	20129
EPTT Metrics						
% EPTT	43.1	44.6	31.1	29.9	38.5	37.2
% Ephemeroptera	35.2	34.8	14.9	15.6	21.4	22.2
% Plecoptera	0.8	--	0.1	0.4	0.2	0.4
% Trichoptera	7.1	9.8	16.1	14.0	16.8	14.6
Percent Dominant Families						
Elmidae	15.3	15.0	10.6	23.3	27.6	28.7
Chironomidae	15.3	25.3	21.3	7.5	12.5	11.8
Heptageniidae	10.9	0.1	0.1	5.9	7.1	8.3
Pleuroceridae	9.5	0.3	26.7	5.2	4.1	4.0
Caenidae	9.5	10.4	1.6	0.5	1.9	2.1
Leptohyphidae	5.1	22.6	10.5	0.6	0.5	0.4
Leptoceridae	1.4	3.5	3.2	1.1	3.0	2.3
Hydropsychidae	3.4	2.9	9.9	3.6	8.3	8.2
Psephenidae	2.8	0.4	0.4	10.7	2.3	4.3
Glossosomatidae	0.2	0.2	--	5.8	1.7	1.2
Isonychiidae	4.7	1.6	2.0	3.2	5.3	6.1
Percent Dominant Taxa						
<i>Elimia</i>	9.4	0.3	26.7	5.2	4.1	4.0
<i>Caenis latipennis</i>	5.4	9.9	1.7	0.4	1.9	2.1
<i>Tricorythodes</i>	5.1	22.6	10.5	0.6	0.5	0.4
<i>Optioservus sandersoni</i>	5.1	0.6	0.3	3.1	4.2	2.4
<i>Stenelmis</i>	4.9	7.4	3.3	16.6	15.5	14.0
<i>Microcyloepus pusillus</i>	0.4	6.7	5.9	2.6	1.7	2.7
<i>Tanytarsus</i>	2.1	5.4	4.9	0.6	0.2	0.5
<i>Cheumatopsyche</i>	2.7	2.9	9.8	3.5	7.2	6.8
<i>Parachaetocladius</i>	--	3.0	7.7	0.1	0.3	0.1
<i>Psephenus herricki</i>	2.5	0.4	0.3	10.4	2.3	3.9
<i>Agapetus</i>	0.01	--	--	5.8	1.7	1.2
<i>Baetis</i>	2.0	--	--	4.3	3.1	2.8
<i>Isonychia bicolor</i>	4.6	1.6	2.0	3.2	5.3	6.1
<i>Dubiraphia</i>	4.2	0.3	0.7	0.3	4.9	7.6

BIOREF stream data values are average percent ($n = 23$).

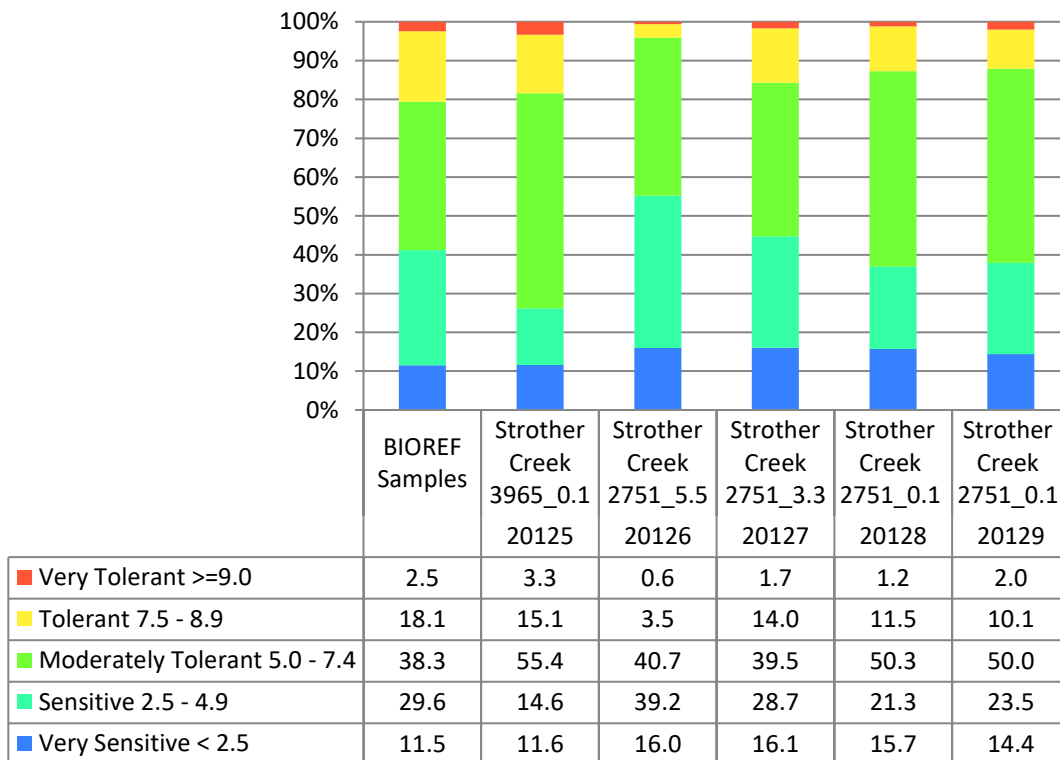
Values in bold type represent the five dominant macroinvertebrate taxa for each station.

Sensitive Taxa

The largest percentage of taxa in each Strother Creek sample had BI values in the moderately tolerant range, with values ranging from 39.5 percent at station 2751_3.3 to 55.4 at station 3965_0.1 (Figure 4). All of these values ranged from similar to much higher compared to reference conditions. Station 2751_5.5 had the highest percentage of taxa in the sensitive range and was much higher than the other Strother Creek stations and BIOREF streams. Compared to reference conditions, the percent sensitive taxa values for the remaining Strother Creek stations ranged from slightly lower at station 2751_3.3 to much lower at the most upstream station (station 3965_0.1). For the very sensitive range, the value at station 3965_0.1 was lower than the other Strother Creek stations but similar to the BIOREF streams.

Compared to reference conditions, values for the tolerant category ranged from much lower at station 3751_5.5 to slightly lower at stations 2751_3.3 and 3965_0.1. Values for the very tolerant range were slightly higher than BIOREF streams at station 3965_0.1 but lower at the three downstream stations. These results indicate that the macroinvertebrate community was more tolerant at the most upstream Strother Creek station (3965_0.1) than the other Strother Creek stations and the BIOREF streams.

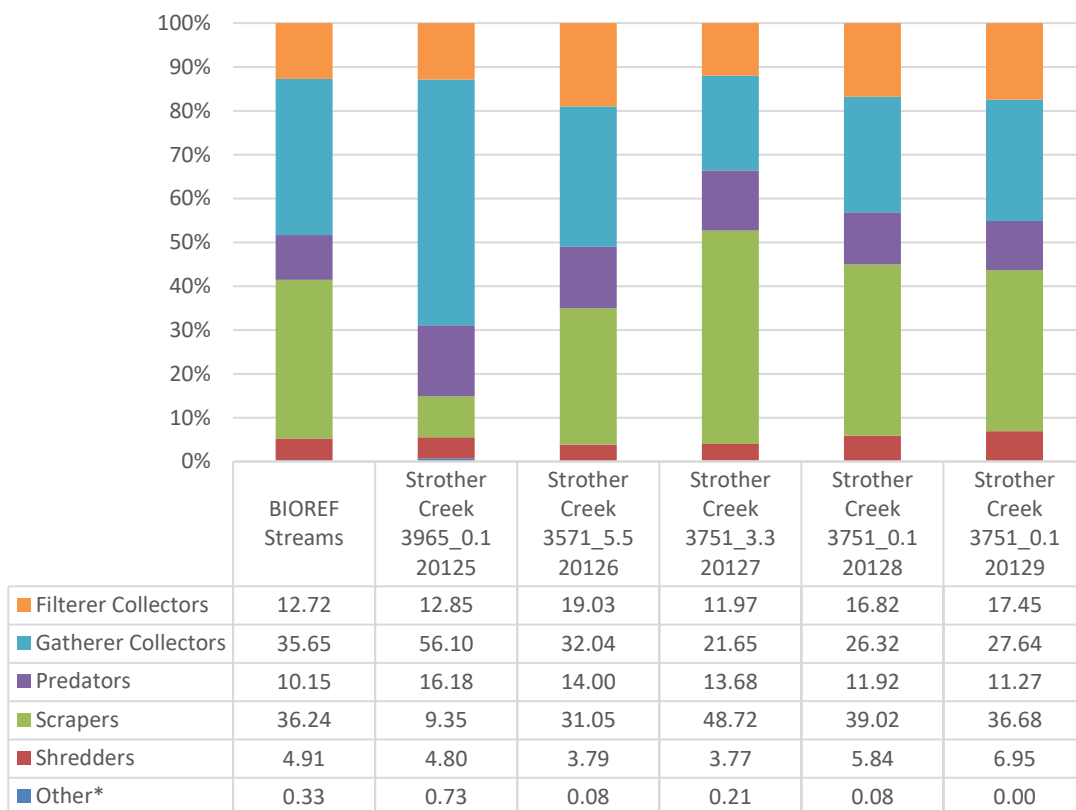
Figure 4. Fall 2020 Percent Taxa by Biotic Index Range



Functional Feeding Groups (FFG)

Scrapers and gatherer-collectors were the most abundant functional feeding group (FFG) categories among BIOREF streams, making up 36.2 percent and 35.7 percent, respectively (Figure 5). These two FFG categories also made up the majority of Strother Creek samples. Percent gatherer-collectors was much higher (56 percent) at the upstream station (3965_0.1) while the remaining Strother Creek stations had values that were lower than reference conditions. Compared to BIOREF streams, percent scrapers were much lower at station 3965_0.1 while the other stations ranged from slightly lower at station 3751_5.5 to much higher at station 3751_3.3. For percent predators, values ranged from slightly higher at the most downstream station (3751_0.1) to about 6 percent higher at the most upstream Strother Creek station (3965_0.1) compared to the BIOREF samples. Filterer values at stations 3965_0.1 and 3751_3.3 were similar, while the other two stations had values that were slightly higher than BIOREF streams. Shredder values were low at all Strother Creek stations and ranged from slightly lower at station 3751_5.5 to slightly higher at station 3751_0.1 compared to reference conditions.

Figure 5. Fall 2020 Percent of Taxa by Functional Feeding Group



*Percent other included piercers, parasites, and taxa that have not been assigned to a FFG

5.3.1.2 Spring 2021 Sampling Season

Macroinvertebrate Community Composition

Table 6 compares the spring 2021 macroinvertebrate community among stations. Figure 6 depicts the percent taxa by BI ranges, and Figure 7 illustrates the percent of taxa by primary functional feeding group (FFG) for each spring sample.

Percent EPT taxa in Strother Creek ranged from about 42 percent at the two upstream stations (3965_0.1 and 2751_5.5) to about 54 percent at station 2751_0.1, the downstream station (Table 6). The farthest upstream sample (station 3965_0.1) had the greatest percent Ephemeroptera; however, all of the mayflies except for one heptageniid specimen of *Stenonema femoratum* were either *Tricorythodes* or *Caenis latipennis*. Mayflies at station 2751_5.5 also consisted mostly of *Tricorythodes* and *C. latipennis*. By comparison, *Tricorythodes* was absent, and *C. latipennis* made up a lower percentage of the two downstream station samples; however, Heptageniidae and Ephemerillidae (primarily *Eurylophella bicolor*) were much more abundant. Compared to BIOREF data, *E. bicolor* was much more abundant, and heptageniid mayflies were less abundant at the two downstream stations. However, heptageniid mayflies were diverse with *Stenonema bednariki*, *S. mediopunctatum*, *S. pulchellum*, and *S. femoratum* being present in samples. In contrast, only one *S. femoratum* specimen was collected in the sample collected at station 3965_0.1, and heptageniid mayflies were absent at station 2751_5.5.

Plecoptera were found in low abundance at the two upstream stations, especially at station 3965_0.1, but they were very abundant at the two downstream stations. Compared to BIOREF streams, stoneflies made up a much higher percentage the two downstream Strother Creek samples. Stoneflies from the family Leuctridae made up most of the stonefly abundance at all Strother Creek stations.

Percent Trichoptera was higher in Strother Creek samples than the BIOREF streams. Most of the caddisfly abundance in Strother Creek was made of *Oxyethira* (family Hydroptilidae), *Cheumatopsyche* (family Hydropsychidae), and *Helicopsyche* (Family Helicopsychidae).

Chironomids made up about 15 to 24 percent of Strother Creek samples, which was lower than the average percent of BIOREF streams. Most of the chironomid abundance at the Strother Creek stations was made up of *Cricotopus/Orthocladius* group, *Tanytarsus*, *Stempellinella*, *Parametriocnemus*, and *Thienemannimyia* group.

Other notable taxa collected in spring 2021 were the snail family Pleuroceridae, riffle beetle family Elmidae, and the crane fly family Limoniidae. The pleurocerid snail *Elimia* made up 18.2 percent of the station 2751_5.5 sample and was much more abundant than the other Strother Creek stations and the BIOREF streams. The riffle beetle *Stenelmis* was common in Strother Creek samples and the BIOREF streams, with highest abundance occurring at the upstream Strother Creek station (3965_0.1). The crane fly

Hexatoma was much more abundant at the two upstream stations than the other Strother Creek stations and BIOREF streams.

Table 6. Percent EPTT, Dominant Family, and Dominant Taxa at the Strother Creek Study Stream Stations and the Ozark/Black/Current EDU Biological Criteria Reference Samples, Spring 2021

Variable-Station	BIOREF Samples	Strother Creek 3965_0.1	Strother Creek 2751_5.5	Strother Creek 2751_3.3	Strother Creek 2751_0.1
Sample Number		21068	21069	21070	21071
% EPTT	33.4	42.0	41.6	51.2	53.6
% Ephemeroptera	22.8	34.6	22.8	20.3	29.2
% Plecoptera	5.5	0.6	3.4	11.6	9.4
% Trichoptera	5.1	6.8	15.3	19.3	15.0
Percent Dominant Family					
Chironomidae	37.6	23.7	14.8	23.8	16.7
Pleuroceridae	8.0	1.9	18.2	5.0	2.2
Elmidae	7.9	10.2	4.3	3.2	10.0
Heptageniidae	7.3	0.1	--	2.5	3.4
Ephmerellidae	5.4	--	0.2	10.7	19.6
Leptohyphidae	1.2	22.1	16.7	--	--
Caenidae	3.9	12.4	5.7	3.9	5.0
Limoniidae	0.6	12.3	11.4	1.5	1.3
Hydroptilidae	0.4	2.6	8.1	5.5	4.0
Leuctridae	3.2	0.3	2.1	10.1	7.2
Hydropsychidae	1.9	0.6	2.2	6.6	3.1
Percent Dominant Taxa					
<i>Cricotopus/Orthocladius</i> grp.	8.5	3.2	1.1	2.9	4.6
<i>Elimia</i>	8.0	1.9	18.2	5.0	2.2
<i>Tanytarsus</i>	5.2	3.5	1.9	6.0	1.7
<i>Stenelmis</i>	4.0	8.4	3.1	1.5	5.0
<i>Stempellinella</i>	3.2	4.1	2.6	3.6	0.6
<i>Tricorythodes</i>	1.2	22.1	16.7	--	--
<i>Caenis latipennis</i>	3.1	12.4	5.7	3.9	5.0
<i>Hexatoma</i>	0.5	12.3	11.4	0.8	1.1
<i>Oxyethira</i>	0.1	2.3	7.1	4.9	3.5
<i>Eurylophella bicolor</i>	2.3	--	0.2	10.5	18.9
<i>Leuctridae</i>	1.0	0.3	2.1	10.1	7.2
<i>Cheumatopsyche</i>	1.8	0.6	2.2	6.1	2.6

BIOREF stream data values are average percent ($n = 22$).

Values in bold type represent the five dominant macroinvertebrate taxa for each station.

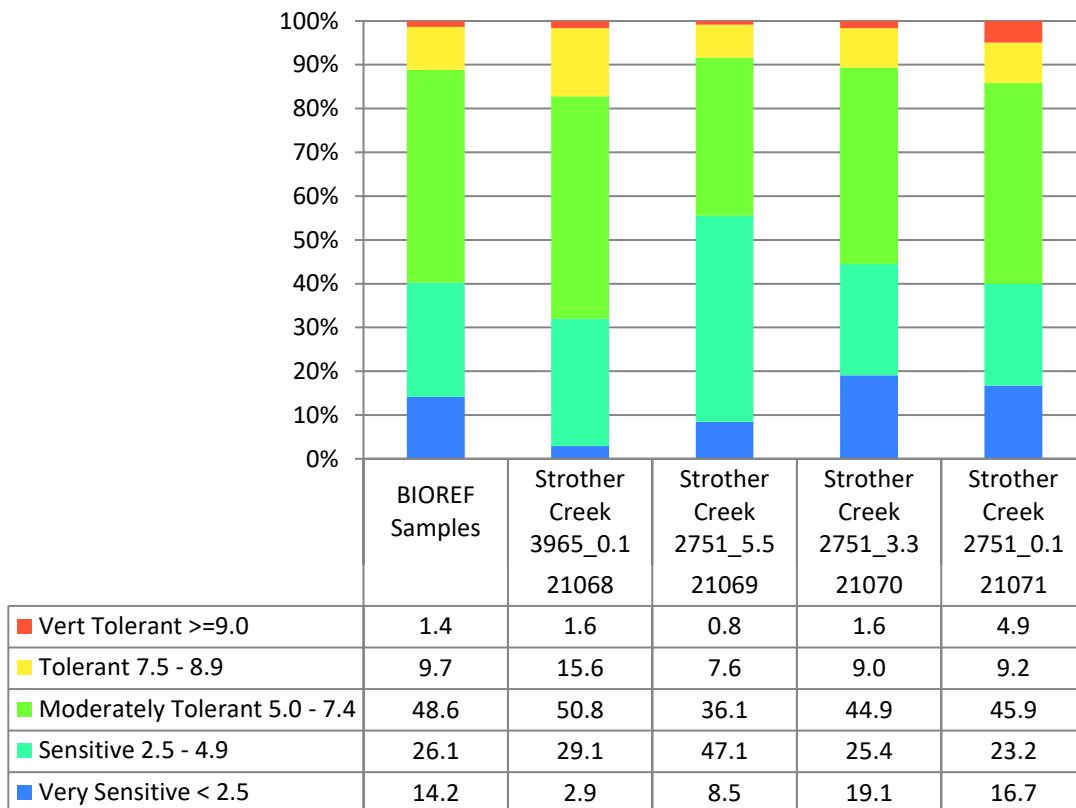
Sensitive Taxa

With the exception of station 2751_5.5, the highest percentage of taxa in Strother Creek samples had BI values in the moderately tolerant range, with values ranging from 36.1 percent at station 2751_5.5 to 50.8 percent at station 3965_0.1 (Figure 6). These values ranged from much lower at station 2751_5.5 to a similar percentage at station 3965_0.1 compared to reference conditions. At station 2751_5.5, the highest percentage of taxa in

the sample was in the sensitive range and was much higher than other Strother Creek stations and the BIOREF streams. Values for the sensitive range at the other Strother Creek stations ranged from slightly lower to a little higher than reference conditions. The two upstream Strother Creek stations had much lower percentages of very sensitive taxa than the downstream stations and BIOREF streams.

The upstream station, 3965_0.1, had the highest percentage of taxa in the tolerant range and was much higher than the other Strother Creek stations and BIOREF streams. For the very tolerant range, the downstream station (2751_0.1) had the highest value and was much higher than the other Strother Creek stations and reference conditions. These results indicate that the macroinvertebrate community was generally more tolerant at the most upstream Strother Creek station (3965_0.1) than the other Strother Creek stations and the BIOREF streams.

Figure 6. Spring 2021 Percent Taxa by Biotic Index Range

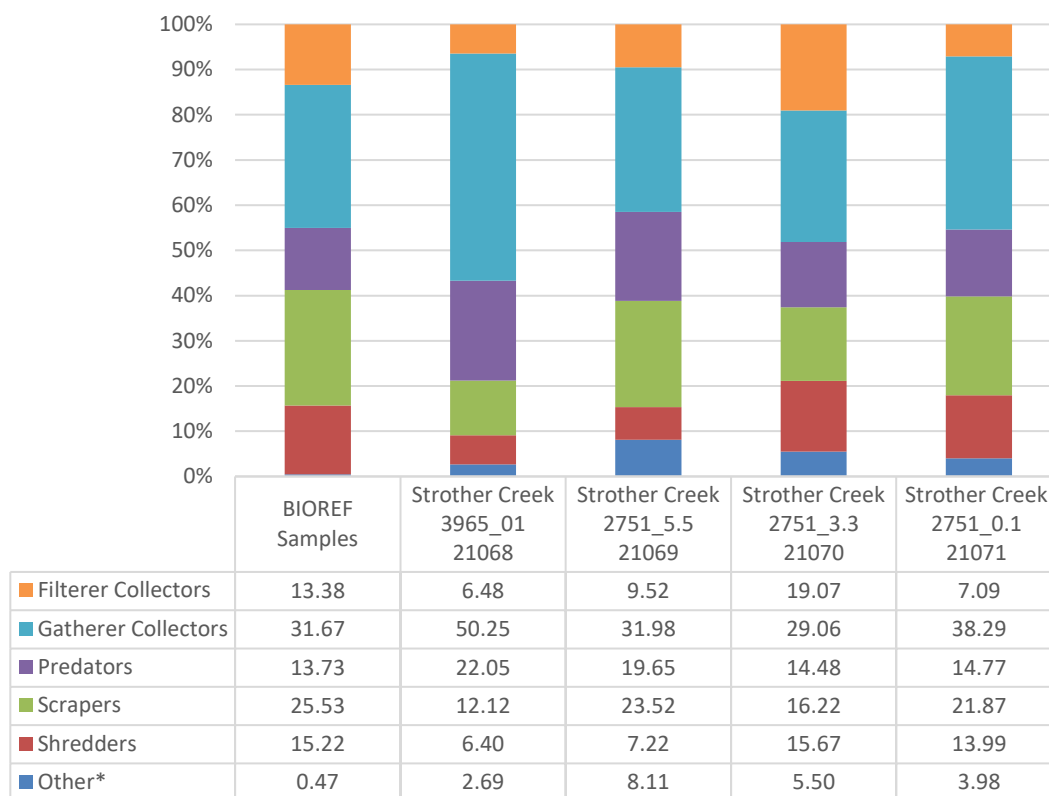


Functional Feeding Groups (FFG)

Gatherer-collector was the most abundant FFG category, ranging from 29.1 percent to 50.3 percent of samples (Figure 7). Scrapers were the second most abundant FFG in Strother Creek samples, with the exception of stations 3965_0.1 and 2751_3.3. Predators made up a large percentage of Strother Creek samples and compared to reference

conditions ranged from slightly higher at the downstream station (2751_0.1) to much higher at the upstream station (3965_0.1). Percent filterers were lower among Strother Creek than the BIOREF streams except station 2751_3.3. Percent shredders were much lower at the two upstream stations, and the two downstream stations had values similar to reference conditions.

Figure 7. Spring 2021 Percent of Taxa by Functional Feeding Group



*Percent other included piercers, parasites, and taxa that have not been assigned to a FFG

5.4 Physicochemical Water Parameters

Strother Creek discharge and physicochemical water chemistry results are presented in Tables 7 and 8. Although there are currently no nutrient criteria in place for Missouri streams and rivers, nutrient and turbidity parameters in Strother Creek were compared to the EPA's *Ambient Water Quality Criteria Recommendations for Rivers and Streams in Nutrient Ecoregion XI* (U.S. EPA 2000) for the Ozark Highlands ecoregion.

Recommended values for the Ozark Highlands are: 0.239 mg/L nitrate plus nitrite as N, 0.38 mg/L total nitrogen, 0.007 mg/L total phosphorus, and 1.43 NTU turbidity.

Fall 2020

Strother Creek fall 2020 water quality data are presented in Table 7. All Strother Creek stations met Missouri's WQS in fall 2020, but all samples also exceeded the EPA's recommendations for nitrate plus nitrite as N and total nitrogen. Parameters such as dissolved oxygen, pH, total phosphorus, total suspended solids, and dissolved cadmium

were similar among all four stations. Conductivity, chloride, and sulfate were elevated compared to reference conditions, especially at the two upstream sites. BIOREF conductivity ranged from 27.3 to 355 $\mu\text{mhos/cm}$, chloride ranged from 1.22 to 2.55 mg/L, and sulfate ranged from 4.41 to 6.46 mg/L. By comparison, conductivity ranged from 802 to 1328 $\mu\text{mhos/cm}$, chloride ranged from 23.2 to 45.1 mg/L, and sulfate ranged from 237 to 606 mg/L among Strother Creek sites. Other parameters such as turbidity, nitrate + nitrite, total nitrogen, ammonia as N, hardness, and many of the dissolved metals (arsenic, calcium, lead, magnesium, nickel) were higher at the upstream stations and decreased toward the most downstream station. Dissolved barium displayed the opposite trend and was highest at the downstream stations.

Table 7. Physicochemical Variables for Surface Water Samples at the Strother Creek Stations, Fall 2020

	Strother Creek 3965_0.1	Strother Creek 2751_5.5	Strother Creek 2751_3.3	Strother Creek 2751_0.1	
Sample Number	20002246	20002247	20002248	20002251	20002252
Sample Date	09/29/2020	09/29/2020	09/29/2020	09/30/2021	09/30/2021
Sample Time	1050	1252	1500	0900	0900
Dissolved Oxygen	8.69	8.24	9.05	8.69	8.71
pH (standard units)	8.0	7.97	8.04	7.95	7.97
Conductivity ($\mu\text{mhos/cm}$)	1328	1279	1021	803	802
Temperature ($^{\circ}\text{C}$)	19.6	19.8	19.0	16.4	16.4
Turbidity (NTU)	1.13	0.76	0.36	0.36	0.36
Discharge (cfs)	23.1	24.5	28.4	19.8	19.4
Ammonia	0.55	0.38	<0.02 ^b	<0.02 ^b	0.05 ^c
Chloride	45.1	42.7	31.7	23.2	23.6
Sulfate	606 ^a	584 ^a	402 ^a	246 ^a	237 ^a
Total Suspended Solids	<5 ^b	<5 ^b	<5 ^b	<5 ^b	<5 ^b
Dissolved Calcium	107	103	84.4	70.2	71.4
Dissolved Magnesium	91.0	86.9	68.3	52.3	52.2
Hardness as CaCO_3	642	614	492	391	393
Dissolved Arsenic ($\mu\text{g/L}$)	1.06	0.94 ^c	0.59 ^c	<0.5 ^a	<0.5 ^a
Dissolved Barium ($\mu\text{g/L}$)	22.4	25.5	37.0	44.2	44.5
Dissolved Cadmium ($\mu\text{g/L}$)	<0.1 ^b	<0.1 ^b	<0.1 ^b	<0.1 ^b	<0.1 ^b
Dissolved Copper ($\mu\text{g/L}$)	0.68 ^c	0.71 ^c	0.66 ^c	<0.5 ^a	<0.5 ^a
Dissolved Lead ($\mu\text{g/L}$)	1.69	1.44	0.68 ^c	<0.5 ^a	<0.5 ^a
Dissolved Nickel ($\mu\text{g/L}$)	22.5	19.9	13.5	8.12	8.20
Dissolved Zinc ($\mu\text{g/L}$)	21.4	24.3	23.3	16.3	15.9
Nitrate + Nitrite	1.31	1.33	1.02	0.63	0.63
Total Nitrogen	2.12	1.92	1.18	0.70	0.70
Total Phosphorus	<0.005 ^b	<0.005 ^b	<0.005 ^b	<0.005 ^b	<0.005 ^b

^aSample diluted during analysis.

^bBelow detectable limits.

^cEstimated values - detected below practical quantitation limit.

Units mg/L unless otherwise noted. Values in bold exceed Missouri WQS or are elevated compared to EPA recommended reference condition values.

Spring 2021

All spring 2021 water samples collected from Strother Creek stations met Missouri's WQS (Table 8); however, turbidity, nitrate plus nitrite as N, and total nitrogen exceeded EPA's recommendations (U.S. EPA 2000) for all four stations. Turbidity may have been elevated due to a recent rain event. Dissolved oxygen, pH, total phosphorus, total suspended solids, and dissolved cadmium were similar among all four stations. Parameters such as conductivity, total nitrogen, ammonia as N, sulfate, chloride, hardness, and many of the dissolved metals (arsenic, calcium, copper, lead, magnesium, nickel, and zinc) were higher at upstream stations and decreased toward the downstream stations. Temperature, discharge, and dissolved barium had the opposite trend and increased as samples were collected farther downstream. Sulfate, chloride, and conductivity readings all were considerably lower in spring compared to fall. Discharge was much higher in the spring and ranged from 43.4-109 cfs.

Although dissolved lead and zinc concentrations were also higher in the spring than the fall, values were below WQS hardness based chronic toxicity values. Lead values ranged from 1.63 µg/L at the most downstream station (2751_0.1) to 5.55 µg/L at the most upstream station (3965_0.1) for the duplicate sample 21000428. By comparison, chronic toxicity values ranged from 4.94 µg/L at Strother Creek 2751_0.1 to 7.65 µg/L at Strother Creek 3965_0.1, based on hardness values at those sites. Zinc values ranged from 35.3 µg/L at the most downstream station (2751_0.1) to about 99 µg/L for both duplicate samples collected at the most upstream station (3965_0.1). By comparison, chronic zinc toxicity values ranged from 199.56 µg/L at Strother Creek 2751_0.1 to 282.64 µg/L for duplicate sample 21000429 and 283.49 µg/L for duplicate sample 21000428 at Strother Creek 3965_0.1, based on hardness values at those sites.

Table 8. Physicochemical Variables for Surface Water Samples at the Strother Creek Stations, Spring 2021

	Strother Creek 3965_0.1		Strother Creek 2751_5.5	Strother Creek 2751_3.3	Strother Creek 2751_0.1
Sample Number	21000428	21000429	21000427	21000425	21000426
Sample Date	03/22/2021	03/22/2021	03/22/2021	03/22/2021	03/22/2021
Sample Time	1030	1030	1200	1355	1522
Dissolved Oxygen	10.68	10.68	10.50	10.33	10.25
pH (standard units)	8.04	8.05	8.07	8.09	8.0
Conductivity (µmhos/cm)	659	664	600	435	387
Temperature (°C)	10.8	10.8	11.1	11.9	12.2
Turbidity (NTU)	3.01	3.12	1.99	1.70	2.08
Discharge (cfs)	43.4	43.1	54.9	92.8	109
Ammonia	0.44	0.44	0.33	0.12	0.05
Chloride	17.1	17.3	15.5	8.36	8.02
Sulfate	194 ^a	201 ^a	167 ^a	97	83.1
Total Suspended Solids	<5 ^b	<5 ^b	<5 ^b	<5 ^b	<5 ^b
Dissolved Calcium	53.2	53.3	49.7	38.0	36.0
Dissolved Magnesium	36.5	36.2	33.0	25.4	23.7
Hardness as CaCO ₃	283	282	260	199	187
Dissolved Arsenic (µg/L)	1.25	1.22	1.04	0.53 ^c	<0.5 ^b
Dissolved Barium (µg/L)	18.8	18.4	19.8	21.7	22.2
Dissolved Cadmium (µg/L)	<0.1 ^b	<0.1 ^b	<0.1 ^b	<0.1 ^b	<0.1 ^b
Dissolved Copper (µg/L)	0.93 ^c	0.94 ^c	0.79 ^c	0.70 ^c	0.60 ^c
Dissolved Lead (µg/L)	5.55	5.46	4.80	2.29	1.63
Dissolved Nickel (µg/L)	27.1	27.1	21.9	11.2	7.74
Dissolved Zinc (µg/L)	98.7	98.9	84.2	46.2	35.4
Nitrate + Nitrite	0.96	0.95	0.74	0.49	0.51
Total Nitrogen	1.34	1.38	1.14	0.71	0.60
Total Phosphorus	<0.005 ^b	<0.005 ^d	<0.005 ^b	<0.005 ^b	<0.005 ^b

^aSample diluted during analysis.

^bBelow detectable limits.

^cEstimated values - detected below practical quantitation limit.

^dAnalyte present in blank at >1/2 or reported value

Units mg/L unless otherwise noted. Values in bold exceed Missouri WQS or are elevated compared to EPA recommended reference condition values.

5.5 Chemical Analysis of Fine Sediments

Table 9 displays the results for Strother Creek and Neals Creek fine sediment metals analysis. All values were below their respective probable effect concentrations (**PEC**); however, there were substantially higher nickel and lead concentrations in the two most upstream Strother Creek stations (3965_0.1 and 2751_5.5) than the two downstream stations (2751_3.3 and 2751_0.1). The probable effects quotient (**PEQ**) is calculated by dividing the metals concentration in a sample by the PEC value. Stations 3965_0.1 and 2751_5.5 had PEQ values for nickel of 0.96 and 0.90, respectively. In comparison, stations 2751_3.3 and 2751_0.1 had PEQ values of 0.55 and 0.28. The PEQ values for the two most upstream stations indicate that nickel concentrations are elevated, and could potentially cause adverse effects to certain sensitive taxa. Cadmium concentrations were very low and were only able to be estimated. For Neals Creek, all PEC values were well

below the PEC threshold limits for the two samples collected in 2021. The only values that were somewhat elevated at Neals Creek were nickel and zinc in the March 16, 2021, sample. Total organic carbon (TOC) was considerably higher in the sediment sample from Strother Creek 3965_0.1 compared to the other samples.

Table 9. Results from fine sediment analysis for Strother and Neals creeks.

Stations	Strother Creek 3965_0.1	Strother Creek 2751_5.5	Strother Creek 2751_3.3	Strother Creek 2751_0.1	Neals Creek 2752_1.2	Neals Creek 2752_1.2	PEC Limit
Parameters							
Sampling Date	05/05/21	05/05/21	05/05/21	05/05/21	03/16/21	12/07/21	--
Sampling time	1025	1048	1203	1310	0800	1030	--
Arsenic (mg/kg) (PEQ)	6.22 (0.19)	6.83 (0.21)	4.95 (0.15)	3.28 (0.10)	5.8 (0.18)	5.02 (0.15)	33.0
Cadmium (mg/kg) (PEQ)	<0.1* ND (<0.02)	<0.1* ND (<0.02)	<0.1* ND (<0.02)	<0.1* ND (<0.02)	0.32 (0.06)	0.1 (0.02)	4.98
Chromium (mg/kg) (PEQ)	9.25 (0.08)	10.6 (0.10)	9.97 (0.09)	7.83 (0.07)	19.8 (0.18)	12.8 (0.11)	111.0
Copper (mg/kg) (PEQ)	6.72 (0.05)	4.41 (0.03)	4.34 (0.03)	3.63 (0.02)	3.4 (0.02)	2.71 (0.02)	149.0
Lead (mg/kg) (PEQ)	40.0 (0.31)	39.0 (0.30)	27.1 (0.21)	16.2 (0.13)	29.2 (0.22)	9.25 (0.07)	128.0
Nickel (mg/kg) (PEQ)	46.5 (0.96)	43.9 (0.90)	26.5 (0.55)	13.8 (0.28)	26.6 (0.55)	8.6 (0.18)	48.6
Zinc (mg/kg) (PEQ)	76.3 (0.17)	107.0 (0.23)	83.1 (0.18)	45.1 (0.10)	212 (0.46)	49.4 (0.11)	459.0
TOC (mg/kg)	10700	1170	2130	1740	7250	--	N/A

PEC=Probable Effects Concentration (MacDonald et al. 2000); PEQ=Probable Effects Quotient (metals value/PEC); Qualifiers:*=estimated value due to QC data outside limits and matrix interference, ND=not detected at reported value.

5.6 Quality Assurance/Quality Control (QA/QC)

Duplicate sample difference criteria for physicochemical parameters are specified in the Fiscal Year 2021 Quality Assurance Project Plan (**QAPP**) for Biological Assessment (MoDNR 2020a). The QAPP specifies that the relative percent difference (**RPD**) for any parameter should not exceed 20 percent. Duplicate water quality samples were collected for physicochemical parameters at Strother Creek station 2751_0.1 in fall 2020 and at station 3965_0.1 in spring 2021. All RPD values were less than 20 percent for both duplicate samples collected from Strother Creek.

QSIT results for the fall 2020 macroinvertebrate duplicate samples collected at station 2751_0.1 was 81.7 percent. Rabeni et al. (1999) recommended that QSIT for duplicate samples should be ≥ 70 percent.

6.0 Discussion

6.1 Land Use

Research has shown a significant link between aquatic community health and land use (Harding et al. 1998, Lenat and Crawford 1994, Roth et al. 1996). Overall, land use was similar between the Strother Creek drainage and the BIOREF streams. Strother Creek, BIOREF streams, and the EDU as whole had high percentages of deciduous forest. Strother Creek differed in that its drainage consisted of a higher percent of barren and developed, open land use, which is likely due to mine tailings and county roads within the watershed. Mining historically has been one of the major land uses in this area. According to USGS, production in Buick Mine first occurred in 1969 (USGS 2009). Buick Mine is part of the Viburnum Trend located in southeast Missouri. Mining first occurred in the Viburnum Trend area in 1960 and has grown to be one of the largest producers of galena (PbS) in the world (Seeger 2008).

6.2 Stream Habitat Assessment

Instream habitat variables as well as catchment variables have been shown to influence aquatic communities (Wang et al. 2007, Burdon et al. 2013). Habitat was comparable or even better in some locations along Strother Creek than Blair Creek, a BIOREF stream. All four Strother Creek stations, however, had poor bank vegetative cover. Station 3965_0.1 also had marginal right bank stability and poor right bank riparian width. Intact riparian zones along stream banks are important in maintaining stream health, stream habitat, and healthy water quality (Allan 2004, Waite and Van Metre 2017). Although vegetative protection of the banks was sparse at each station, most had established riparian corridors. Some of these corridors, however, were intersected by county roads and power lines or reduced due to nearby pasture lands. Riparian vegetation positively influences stream ecosystems by providing leaf litter inputs, shading, and reducing inputs of nutrients and other contaminants from the surrounding landscape (Burrell et al 2013).

6.3 Biological Assessment and Macroinvertebrate Community Analyses

Strother Creek stations upstream of Neals Creek (3965_0.1 and 2751_5.5) were categorized as partially supporting, and stations downstream of Neals Creek (2751_3.3 and 2751_0.1) were fully supporting during both sampling seasons. MSCI scores followed a gradient from lowest at the most upstream station to highest at the two downstream stations. The upstream station is located closest to the Buick Mine tailings. Poulton et al. (2009) sampled macroinvertebrates upstream and downstream of Neals Creek and found similar results. In the Poulton et al. (2009) study, the most upstream station had a stream condition index score that was partially supporting, and the downstream station had a score that was fully supporting. Neals Creek discharges a substantial amount of water into Strother Creek and may be diluting some of the contaminants potentially percolating from the Buick Mine tailings. Negative effects of mining and metals on aquatic communities is well documented (e.g. Allert et al. 2009, Besser et al. 2007, Courtney and Clements 2002, Poulton et al. 2009).

Not only did MSCI scores change from upstream to downstream, but so did the dominant taxa. Chironomidae was a dominant family at all four stations, but they made up a greater

percentage of the total taxa for stations 3965_0.1 and 2751_5.5 during the fall 2020 sampling season. In spring 2021, Chironomidae was generally the dominant family in Strother Creek samples, but they were not consistently higher in the upstream stations and were lower than the average percent for the BIOREF streams. At the two upstream stations, mayflies were dominated by *Tricorythodes* and *Caenis latipennis*; however, they were in low abundance or absent at the downstream stations. An opposite trend occurred for mayflies that are known to be sensitive to metals. Heptageniidae mayflies were fairly abundant, especially during the fall 2020 sampling season, at downstream stations 2751_3.3 and 2751_0.1; however, they were scarce or absent at upstream stations 3965_0.1 and 2751_5.5 during both sampling seasons. Similarly, Baetidae mayflies were also scarce in the two most upstream stations during the fall 2020 sampling season, and Ephemerellidae were relatively reduced during the spring 2021 sampling season. Both of these families, however, were common downstream. Heptageniidae, Baetidae, and Ephemerellidae mayflies have been shown to be highly sensitive to metals contamination (Clements et al. 2019, Courtney and Clements 2002). The higher concentrations of metals such as nickel and lead in the water and sediment at stations 3965_0.1 and 2751_5.5 are likely altering the macroinvertebrate community composition at these two upstream stations.

During both sampling seasons, Strother Creek 3965_0.1 had a lower percentage of intolerant taxa (BI<5.0) than the remaining downstream stations. The other stations had percent intolerant taxa that were either similar to or higher than the average of BIOREF samples. Strother Creek station 3965_0.1 also had much lower percentages for the scraper FFG during both sampling seasons. Clements et al. (2019) found that scrapers are very sensitive to such metals as copper, iron, and zinc. Despite having the lowest TR and SDI values during both sampling seasons, station 2751_5.5 had the greatest percent intolerant taxa because the samples were dominated by the snail *Elimia*, which has a BI value of 2.5 (MoDNR 2021). The abundance of *Elimia* collected from station 2751_5.5 during both sampling seasons likely skewed the overall BI to a lower value.

6.4 Physicochemical Water Parameters

Overall, water samples collected from Strother Creek met all of Missouri's WQS for both sampling seasons. Although WQS were met, parameters such as conductivity, total nitrogen, sulfate, dissolved lead, and dissolved nickel were elevated in the two upstream Strother Creek stations. Sulfate concentrations were sufficiently elevated at some stations to require dilution during laboratory analysis. Sulfate is a common byproduct of mining and can be found in milling agents (Blevins 1986, Seeger 2008). Chloride levels were also elevated in fall of 2020 at the two upstream stations. Chloride levels were 45.1 mg/L and 42.7 mg/L at stations 3965_0.1 and 2751_5.5, respectively. Miltner (2021) found that sulfate concentrations of 152 mg/L and chloride concentrations of 52 mg/L could be hazardous to sensitive macroinvertebrate taxa in Ohio streams and generally were more toxic to mayflies than other taxonomic groups. The same study found that two mayfly taxa, *Stenonema mediopunctatum* and *Eurylophella*, that were more common at the two downstream Strother Creek stations, were very sensitive to elevated levels of chloride, and *S. mediopunctatum* was also sensitive to elevated levels of sulfate. But the mayfly

genera *Caenis* and *Tricorythodes*, which were much more common at the two upstream Strother Creek stations, were found to be tolerant of elevated levels of chloride and sulfate (Miltner 2021). Sulfate levels in Strother Creek exceeded Miltner's (2021) suggested hazardous concentration for all stations in fall of 2020 and the two upstream stations in spring of 2021.

Nutrient concentrations for total nitrogen and nitrate+nitrite as N were consistently elevated for all Strother Creek samples compared to EPA's recommended nutrient criteria (U.S. EPA 2000). Seeger (2008) noted that nutrients might be released from unused milling and blasting agents. It is also possible nutrients are entering the stream from nearby cattle farms. An increase of filamentous algae was observed at stations 2751_5.5 and 2751_3.3. Increases in nutrients have been linked to increases in algal growth and changes to the macroinvertebrate community (Femmer 2011, Justus et al. 2009).

6.5 Chemical Analysis of Fine Sediment

Fine sediment samples indicated that metals concentrations were under PEC levels established by MacDonald et al. (2000). Lead and nickel concentrations followed a longitudinal gradient from highest at the most upstream station (closest to Buick Mine tailings) to lowest in the most downstream station. Station 2751_0.1 had the lowest metals concentrations for all parameters except cadmium, which was similarly low for all stations. Nickel concentrations, however, were near PEC threshold limits at the two upstream stations. PEQ values of sediment samples from stations 3965_0.1 and 2751_0.1 were 0.96 and 0.90, respectively. The lower concentrations of metals such as nickel and lead downstream of Neals Creek indicates that Neals Creek is likely not contributing additional metal contaminants to Strother Creek, but rather may be diluting contaminants or helping to move fine sediment farther downstream. Metals concentrations in Neals Creek collected in 2021 were much lower than PEC threshold limits and were likely not affecting downstream Strother Creek sampling stations (Table 9). Additional macroinvertebrate and water sampling on Neals Creek could test the hypothesis that Neals Creek is diluting contaminants at the downstream Strother Creek sampling stations.

7.0 Summary

Five null hypotheses were stated in the introduction.

- 1) Stream habitat assessment scores of Strother Creek will be similar to a representative BIOREF stream (Blair Creek). This hypothesis is accepted. The SHAPP scores were comparable.
- 2) The macroinvertebrate community will be similar among stations located longitudinally along Strother Creek. This hypothesis is rejected. The two upstream stations (3965_0.1 and 2751_5.5) had substantially lower MSCI and biological metric scores than the two downstream stations. There were also differences in dominant taxa among stations.

3) The macroinvertebrate community in Strother Creek will be similar to the macroinvertebrate community of BIOREF streams in the Ozark/Black/Current EDU. This hypothesis is rejected. Stations 3965_0.1 and 2751_0.1 were categorized as partially supporting. However, 2751_3.3 and 2751_0.1 had metric scores similar to BIOREF streams.

4) Physicochemical water quality of Strother Creek will meet Missouri's WQS and EPA's recommended values. This hypothesis is partially accepted. Physicochemical water quality met Missouri's WQS, but it did not meet EPA's recommended nutrient criteria for rivers and streams in nutrient ecoregion XI (U.S. EPA 2000).

5) Sediment metals concentrations will be below probable effects concentrations (PECs). This hypothesis is accepted. Although nickel concentrations in Strother Creek fine sediment samples were close to PEC threshold limits, none were exceeded.

8.0 Conclusion

Compared to BIOREF watersheds from the Ozark/Black/Current EDU, Strother Creek had a slightly higher percentage of developed/barren land use. Mining of lead, zinc, copper, and silver first occurred in this area in the 1960s. Due to metals pollution from the Buick Mine, portions of Strother Creek were placed on the 303(d) list of impaired waters from 2006-2014. Restoration action was able to improve water quality enough to remove Strother Creek from the list of impaired waters.

Our study found that upstream of Neals Creek, Strother Creek did not meet the protection of warm water habitat (aquatic life) designation in the Missouri's WQS since stations 3965_0.1 and 2751_5.5 had partially supporting MSCI scores. All water quality parameters met Missouri's WQS; however, nutrient levels for total nitrogen and nitrate+nitrite as N exceeded EPA's recommended nutrient criteria.

Metals concentrations in fine sediment samples indicated no values above PEC threshold limits. Despite there being no water or fine sediment parameters above standards, there were still several elevated values in samples upstream of Neals Creek. These included conductivity, total nitrogen, nitrate+nitrite as N, chloride, sulfate, dissolved lead, dissolved nickel, and nickel concentrations in fine sediment.

A combination of stressors or pollutants to a stream can result in a nonlinear and greater response than expected in the aquatic community (Kaushal et al. 2019, MacDonald et al. 2009, Segner et al. 2014). Samples taken from Strother Creek represent the water quality for one point in time. Continued monitoring of water quality parameters, metals concentrations in fine sediment, and the macroinvertebrate community will be necessary to evaluate how water quality and stream health is changing over time due to varying levels of stressors.

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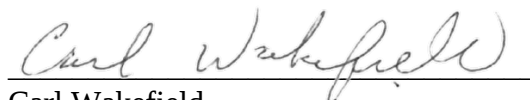
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Submitted by:



Carl Wakefield
Environmental Program Analyst
Water Quality Monitoring Section
Environmental Services Program

Date:

7/26/2023

Approved by:



Scott Robinett
Water Quality Monitoring Section Chief
Environmental Services Program

SR:cwh

c: Robert Voss, WPP
Brad Ledbetter, Southeast Regional Office Director

Appendix A

Invertebrate Database Bench Sheet Report
Fall 2020 and Spring 2021

Strother Creek

Grouped by Season and Station

Invertebrate Bench Sheet Report
Fall 2020

Station: Strother Creek 3965_0.1			
Sample Number: 20125			
Date 9/29/2020			
* - large rare			
ORDER	CS	NF	RM
"HYDRACARINA"			
Acarina	2	1	
BASOMMATOPHORA			
Menetus		1	
Physella			1
COLEOPTERA			
Dubiraphia		1	3
Macronychus glabratus		1	
Microcylloepus pusillus	14	1	67
Optioservus sandersoni	5		2
Psephenus herricki	4		1
Scirtidae			3
Stenelmis	83	6	2
DECAPODA			
Faxonius hylas	*		1
DIPTERA			
Ablabesmyia		3	1
Ceratopogoninae		6	1
Chironomidae	1	10	4
Cladotanytarsus		19	1
Corynoneura	1		2
Cricotopus trifascia		1	
Dasyheleinae	1		
Dicrotendipes		2	1
Djalmabatista		2	1
Forcipomyiinae	1	1	
Hemerodromia	1		
Hexatoma	33	5	1
Labrundinia		1	
Nilothauma		1	
Pagastiella		3	
Parachaetocladius	25	4	8
Parametriocnemus	13		3
Pentaneura	1		1
Polypedilum flavum	7	2	6

Station: Strother Creek 3965_0.1			
Sample Number: 20125			
P. halterale grp		1	
P. illinoense grp	2	5	9
Pseudochironomus		6	
Rheotanytarsus	9	1	3
Simulium	1		4
Stempellinella	14	28	10
Stenochironomus	1	1	6
Synorthocladius	1		
Tabanus	1		
Tanytarsus	19	37	10
Thienemanniella			3
Thienemannimyia grp	1	3	17
Tipula	1	1	
EPHEMEROPTERA			
Caenis anceps	4	2	
Caenis latipennis	16	84	22
Heptageniidae	1		
Isonychia bicolor	18		2
Leptophlebiidae		1	
Tricorythodes	262	4	12
HEMIPTERA			
Veliidae			1
LUMBRICINA			
Lumbricina	1		
MEGALOPTERA			
Corydalus	2		
Nigronia serricornis	1		
NEOTAENIOGLOSSA			
Elimia	2		2
ODONATA			
Argia	10	2	19
Boyeria			1
Calopteryx	1		1
Dromogomphus		1	
Enallagma			3
Gomphidae	30		1
Hagenius brevistylus		1	2
Macromia		1	7
Progomphus obscurus		1	
Stylogomphus albistylus	1		
TRICHOPTERA			

Station: Strother Creek 3965_0.1			
Sample Number: 20125			
Cheumatopsyche	35		1
Chimarra	12	2	3
Glossosoma		1	
Helicopsyche		1	
Hydroptila	1		
Mystacides		1	1
Oecetis	3	2	12
Oxyethira	2		6
Polycentropus	1		13
Triaenodes	1		23
TRICLADIDA			
Planariidae	3		
TUBIFICIDA			
Enchytraeidae	1		
Tubificinae		9	8
VENEROIDA			
Pisidiidae		1	

Station: Strother Creek 2751_5.5			
Sample Number: 20126			
Date 9/29/2020			
* - large rare			
ORDER	CS	NF	RM
"HYDRACARINA"			
Acarina	11	1	4
BASOMMATOPHORA			
Menetus		1	
Physella		1	1
COLEOPTERA			
Dubiraphia		4	5
Ectopria nervosa	1		
Macronychus glabratus	2		4
Microcylloepus pusillus	2	1	68
Optioservus sandersoni	2	1	
Psephenus herricki	1	3	
Scirtidae			1
Stenelmis	39	1	
DECAPODA			
Faxonius hylas	*	*	*
DIPTERA			

Station: Strother Creek 2751_5.5			
Sample Number: 20126			
Ablabesmyia		10	
Atherix	*		
Cladotanytarsus		1	3
Corynoneura			2
Cricotopus trifascia	2		
Cricotopus/Orthocladius	2		
Dixella			1
Forcipomyiinae		1	
Hemerodromia	1		
Hexatoma	34	5	
Nilotanypus			5
Parachaetocladius	72	22	
Parametriocnemus	10	3	
Polypedilum flavum	15		
P. illinoense grp	1		1
Psectrocladius		1	
Pseudochironomus		2	
Rheocricotopus	1		
Rheotanytarsus	7		
Simulium	3		
Stempellinella	2	12	3
Tabanus	*	1	
Tanytarsus	12	38	9
Thienemannimyia grp	3	7	10
Xestochironomus			2
EPHEMEROPTERA			
Caenis latipennis	1	14	5
Eurylophella			1
Isonychia bicolor	22	2	
Leptophlebiidae		4	
Plauditus	1		1
Procloeon		1	
Stenacron	1		
Tricorythodes	126	2	
LUMBRICINA			
Lumbricina	1		1
MEGALOPTERA			
Corydalus	2		
Nigronia serricornis		1	*

Station: Strother Creek 2751_5.5			
Sample Number: 20126			
NEOTAENIOGLOSSA			
Elimia	144	124	56
ODONATA			
Argia		9	5
Boyeria			*
Calopteryx			1
Dromogomphus			*
Gomphidae	4		
Hagenius brevistylus		5	1
Helocordulia		1	
Hetaerina			1
Macromia		2	3
Stylogomphus sigmastylus		7	1
PLECOPTERA			
Chloroperlidae		1	
TRICHOPTERA			
Cheumatopsyche	119		
Chimarra	16		
Hydropsyche morosa grp	1		
Hydroptila		1	
Limnephilidae			1
Oecetis	2	2	12
Polycentropus	1	7	10
Ptilostomis		1	
Triaenodes		1	22
TRICLADIDA			
Planariidae	3		
TUBIFICIDA			
Branchiura sowerbyi			4
VENEROIDA			
Pisidiidae		1	1

Station: Strother Creek 2751_3.3			
Sample Number: 20127			
Date 9/29/2020			
* - large rare			
ORDER	CS	NF	RM
"HYDRACARINA"			
Acarina	9	1	1

Station: Strother Creek 2751_3.3			
Sample Number: 20127			
AMPHIPODA			
Hyalella azteca			59
BASOMMATOPHORA			
Ancylidae		2	1
Helisoma			1
Physella			3
COLEOPTERA			
Ancyronyx variegatus		3	2
Dineutus			*
Dubiraphia			4
Ectopria nervosa		4	
Gyrinus			42
Macronychus glabratus		1	5
Microcylloepus pusillus	3		33
Optioservus sandersoni	30	11	2
Psephenus herricki	26	118	2
Stenelmis	160	68	5
DECAPODA			
Faxonius hylas	1	*	
DIPTERA			
Ablabesmyia	1		2
Atherix	1		
Cardiocladius	1		
Chironomidae		1	
Chrysops			1
Corynoneura	3	2	2
Cricotopus bicinctus	3		3
Cricotopus trifascia	2		
Cricotopus/Orthocladius		2	12
Dicrotendipes			3
Empididae (undescribed)		1	
Forcipomyiinae	3		
Hemerodromia	2		
Labrundinia			4
Limnophila		3	
Nilotanytus			2
Parachaetocladius	1		
Paratanytarsus			5
Pentaneura			1

Station: Strother Creek 2751_3.3			
Sample Number: 20127			
Phaenopsectra			1
Polypedilum flavum	6	2	2
P. illinoense grp	1		2
Rheocricotopus	1		
Rheotanytarsus	3		2
Simulium	22	2	19
Stenochironomus			1
Tabanus		*	
Tanytarsus	2	3	3
Thienemanniella	8	2	6
Thienemannimyia grp		6	5
Tipula	3	1	4
EPHEMEROPTERA			
Acerpenna			2
Anafroptilum			1
Baetis	57		3
Baetisca lacustris		1	
Caenis anceps	1		
Caenis latipennis		4	2
Eurylophella	2	2	1
Heptageniidae	4		3
Isonychia bicolor	41	2	2
Leptophlebiidae		1	
Leucrocuta	7		
Plauditus	4	1	
Stenacron	4	8	1
Stenonema bednariki	9		
Stenonema femoratum		8	
S. mediopunctatum	35		
Stenonema pulchellum	4		
Tricorythodes	6		3
ISOPODA			
Caecidotea (Blind & Unpigmented)	2		
LEPIDOPTERA			
Petrophila		1	1
LUMBRICINA			
Lumbricina	4		1
MEGALOPTERA			
Corydalus	2		

Station: Strother Creek 2751_3.3			
Sample Number: 20127			
Nigronia serricornis		1	
NEOTAENIOGLOSSA			
Elimia	39	6	28
ODONATA			
Argia		39	3
Boyeria			2
Dromogomphus			1
Enallagma	4	6	3
Hagenius brevistylus		1	
Helocordulia			1
Hetaerina			5
Macromia		1	3
Stylogomphus sigmastylus		8	
PLECOPTERA			
Leuctridae	2	1	1
Neoperla		1	
TRICHOPTERA			
Agapetus	81		
Cheumatopsyche	45	2	2
Chimarra	8	8	
Helicopsyche	11		
Hydropsyche morosa grp	2		
Hydroptila		1	
Hydroptilidae	2		
Oecetis	3		7
Polycentropus	1	8	9
Triaenodes			6
TRICLADIDA			
Planariidae	42	13	2

Station: Strother Creek 2751_0.1			
Sample Number: 20128			
Date 9/30/2020			
* - large rare			
ORDER	CS	NF	RM
"HYDRACARINA"			
Acarina		4	
AMPHIPODA			

Station: Strother Creek 2751_0.1			
Sample Number: 20128			
Hyalella azteca			15
BASOMMATOPHORA			
Ancylidae	1	10	5
Helisoma		1	
Lymnaeidae		3	
Menetus		4	
Physella			2
COLEOPTERA			
Ancyronyx variegatus			6
Dubiraphia		35	28
Lutrochus			1
Macronychus glabratus			11
Microcylloepus pusillus	3	3	16
Optioservus sandersoni	40	14	
Psephenus herricki	18	11	1
Stenelmis	162	33	4
DECAPODA			
Faxonius hylas	*		
DIPTERA			
Ablabesmyia		2	2
Anopheles			1
Atherix	5		
Ceratopogoninae	1	13	1
Chironomidae	2		5
Corynoneura	1	6	1
Cricotopus bicinctus			8
Cricotopus/Orthocladius	1	4	29
Dicrotendipes			4
Dixella			1
Djalmabatista		2	
Hemerodromia	1		
Hexatoma	5		
Labrundinia		3	
Microtendipes			2
Nanocladius			1
Parachaetocladius	4		
Parakiefferiella			4
Parametrioctenus	1		
Paratanytarsus			11

Station: Strother Creek 2751_0.1			
Sample Number: 20128			
Polypedilum flavum	1		13
P. illinoense grp			7
Psectrocladius			1
Rheocricotopus	1		
Rheotanytarsus	12		4
Simulium	6		
Stenochironomus		1	
Tabanus	*		
Tanytarsus			3
Thienemanniella	1	1	17
Thienemannimyia grp		2	2
Tipula	1		
Zavreliomyia (Paramerina)			1
EPHEMEROPTERA			
Anafroptilum			1
Baetis	34	1	5
Baetisca lacustris		1	
Caenis anceps	1		
Caenis latipennis		16	8
Ephemerella	2		3
Eurylophella		9	1
Isonychia bicolor	68		
Leptophlebiidae		2	
Leucrocota	4		
Plauditus	15		10
Stenacron		2	
Stenonema bednariki	9	1	
Stenonema femoratum		5	
Stenonema mediopunctatum	39	1	
Stenonema pulchellum	27	3	
Tricorythodes	2	1	4
GORDIOIDEA			
Gordiidae		1	
LEPIDOPTERA			
Petrophila	4		
MEGALOPTERA			
Corydalus	11	*	
NEOTAENIOGLOSSA			

Station: Strother Creek 2751_0.1			
Sample Number: 20128			
Elimia	10	33	10
ODONATA			
Argia	2	16	2
Basiaeschna janata			*
Boyeria		*	4
Calopteryx	1		8
Dromogomphus		3	
Enallagma			6
Hagenius brevistylus		2	*
Macromia		8	*
Stylogomphus sigmastylus		1	
PLECOPTERA			
Acroneuria	2		
Leuctridae		*	
Neoperla	1		
TRICHOPTERA			
Agapetus	22		
Cheumatopsyche	90	3	
Chimarra	8		
Helicopsyche	16	4	1
Hydropsyche morosa grp	12		1
Mystacides	1	5	
Neophylax		1	
Oecetis		3	20
Polycentropus		8	11
Triaenodes	1	1	8
TRICLADIDA			
Planariidae	27	6	
TUBIFICIDA			
Branchiura sowerbyi		3	
VENEROIDA			
Pisidiidae		6	

Station: Strother Creek 2751_0.1			
Sample Number: 20129			
Date 09/30/2020			
* - large rare			
ORDER	CS	NF	RM
"HYDRACARINA"			
Acarina	3	2	
AMPHIPODA			
Allocrangonyx	1	1	
Hyalella azteca		2	27
BASOMMATOPHORA			
Ancylidae		8	
Gyraulus		4	
Helisoma		*	*
Menetus		1	
Physella		6	1
COLEOPTERA			
Ancyronyx variegatus		2	13
Dubiraphia		49	50
Ectopria nervosa		4	
Macronychus glabratus			10
Microcylloepus pusillus	1	3	31
Optioservus sandersoni	28	3	
Psephenus herricki	27	24	
Stenelmis	139	39	3
DECAPODA			
Faxonius hylas	*	*	4
DIPTERA			
Ablabesmyia		2	
Atherix	2	*	
Ceratopogoninae		18	
Chironomidae		1	2
Corynoneura		1	
Cricotopus bicinctus			6
Cricotopus/Orthocladius	6		35
Dicrotendipes			1
Djalmabatista		2	
Eukiefferiella	1		
Hemerodromia	2		
Hexatoma	5	2	
Labrundinia		2	2

Station: Strother Creek 2751_0.1			
Sample Number: 20129			
Microtendipes			1
Pagastiella		2	
Parachaetocladius	1		
Parametriocnemus	2		
Paratanytarsus			3
Pentaneura		1	
Polypedilum flavum	10	3	11
Polypedilum illinoense grp			10
Rheocricotopus	1		
Rheotanytarsus	9		7
Simulium	7		1
Stenochironomus			2
Tabanus	*		
Tanytarsus	1	1	4
Thienemanniella	7	4	4
Thienemannimyia grp		4	3
Tribelos		1	
EPHEMEROPTERA			
Acentrella	5		
Baetis	34		2
Baetisca lacustris		1	
Caenis latipennis		24	3
Eurylophella	2	4	
Heptageniidae	19	2	
Isonychia bicolor	78	1	
Leptophlebiidae		2	1
Leucrocuta	3		
Plauditus	6		4
Procloeon		2	
Stenacron		4	
Stenonema bednariki	5		
Stenonema femoratum		13	1
Stenonema mediopunctatum	30		
Stenonema pulchellum	29	1	
Teloganopsis deficiens	6		
Tricorythodes	3	2	
LEPIDOPTERA			
Petrophila	1		1
LUMBRICINA			

Station: Strother Creek 2751_0.1			
Sample Number: 20129			
Lumbricina		1	
MEGALOPTERA			
Corydalus	2		
NEOTAENIOGLOSSA			
Elimia	10	31	11
Hydrobiidae		1	
ODONATA			
Argia	2	7	2
Boyeria		1	5
Calopteryx			4
Dromogomphus		1	
Enallagma			7
Hagenius brevistylus		5	
Hetaerina		1	3
Macromia		3	7
Ophiogomphus		*	
Stylogomphus sigmastylus		1	
PLECOPTERA			
Acroneuria	1		
Chloroperlidae		1	
Neoperla	3		
Pteronarcys pictetii	*		
TRICHOPTERA			
Agapetus	15	1	
Cernotina		5	8
Cheumatopsyche	83	3	2
Chimarra	6		
Helicopsyche	6	2	2
Hydropsyche morosa grp	12	4	2
Limnephilidae			2
Mystacides		2	
Oecetis	5	3	13
Plectrocnemia		1	1
Polycentropus		1	3
Triaenodes			7
TRICLADIDA			
Planariidae	21	4	1
TUBIFICIDA			
Tubificinae		1	

Station: Strother Creek 2751_0.1			
Sample Number: 20129			
VENEROIDA			
Pisidiidae		4	

Invertebrate Bench Sheet Report
Spring 2021

Station: Strother Creek 3965_0.1			
Sample: 21068			
Date March 22, 2021			
* - large rare			
ORDER	CS	NF	RM
COLEOPTERA			
Berosus		*	
Macronychus glabratus	1		3
Microcylloepus pusillus	9		6
Optioservus sandersoni	2		
Paracymus		1	
Psephenus herricki	7		
Scirtidae			2
Stenelmis	96	4	
Tropisternus			*
DECAPODA			
Faxonius hylas	*	*	*
DIPTERA			
Ceratopogoninae	3		
Cladotanytarsus	4	32	3
Clinocera	4	13	
Cricotopus trifascia	9		2
Cricotopus/Orthocladius	19	2	17
Dicrotendipes			1
Diptera		1	
Djalmabatista		3	
Ephydriidae		1	
Eukiefferiella	1		
Hemerodromia	5	2	5
Hexatoma	113	33	
Hybomitra	1		
Orthocladius (Euorthocladius)	1		
Pagastiella		4	
Parametriocnemus	28	5	2
Paratanytarsus	1	1	8
Pentaneura		2	10
Polypedilum aviceps	1		1

Station: Strother Creek 3965_0.1			
Sample: 21068			
Polypedilum halterale grp		1	
Polypedilum scalaenum grp		4	
Potthastia			1
Procladius		3	
Prosimulium	1		1
Pseudochironomus		1	
Rheotanytarsus			3
Simulium	5	1	4
Stempellinella	20	15	14
Stenochironomus			1
Stictochironomus		1	
Tabanus		1	*
Tanytarsus	16	19	6
Thienemannimyia grp		8	11
Tipula	*	1	1
EPHEMEROPTERA			
Caenis latipennis	52	54	41
Stenonema femoratum		1	
Tricorythodes	144	31	88
GORDIOIDEA			
Gordiidae	*		
LUMBRICINA			
Lumbricina	1		
LUMBRICULIDA			
Lumbriculidae	1		
MEGALOPTERA			
Corydalus	1		
NEOTAENIOGLOSSA			
Elimia	16		6
ODONATA			
Argia	2	4	6
Boyeria			2
Gomphidae	7	3	
Hagenius brevistylus			6
Hetaerina			*
Macromia		1	2
PLECOPTERA			
Amphinemura			1

Station: Strother Creek 3965_0.1			
Sample: 21068			
Clioperla clio			*
Perlesta	1		2
Zealeuctra	2	1	
TRICHOPTERA			
Cheumatopsyche	5	1	1
Chimarra	11	*	1
Glossosomatidae			*
Helicopsyche	10		
Lepidostoma			1
Ochrotrichia	2		2
Oecetis		2	4
Oxyethira	1		26
Plectrocnemia			1
Pycnopsyche		*	2
Triaenodes			11
TRICLADIDA			
Planariidae	4		3
TUBIFICIDA			
Enchytraeidae	1	1	
Limnodrilus hoffmeisteri	1	2	
Tubificinae	3	4	2
VENEROIDA			
Pisidiidae	1		1

Station: Strother Creek 2751_5.5			
Sample: 21069			
Date March 22, 2021			
* - large rare			
ORDER	CS	NF	RM
COLEOPTERA			
Macronychus glabratus			2
Microcylloepus pusillus	6	3	3
Psephenus herricki	1	4	
Stenelmis	33	2	
DECAPODA			
Faxonius hylas		*	
Faxonius punctimanus			1
DIPTERA			
Atherix			*
Ceratopogoninae		3	

Station: Strother Creek 2751_5.5			
Sample: 21069			
Chironomidae		1	
Clinocera	12	1	
Corynoneura		1	
Cricotopus bicinctus	1		4
Cricotopus trifascia	3		5
Cricotopus/Orthocladius	7	1	4
Djalmabatista		9	
Hemerodromia	1	2	3
Hexatoma	69	60	
Hybomitra	1		
Micropsectra	8	10	3
Parachaetocladius	6		
Parametriocnemus	15	4	1
Paratanytarsus		1	
Pentaneura		1	2
Phaenopsectra			1
Polypedilum aviceps	2		1
Polypedilum flavum	1		
Polypedilum illinoense grp		3	
Prosimulium	13		26
Rheotanytarsus	1		2
Simulium			8
Stempellinella	5	19	5
Tabanus	*		
Tanytarsus	7	15	
Thienemannimyia grp	2	10	7
Tipula	1	1	1
EPHEMEROPTERA			
Caenis latipennis	7	25	33
Eurylophella bicolor		2	
Isonychia bicolor			2
Leptophlebiidae			1
Tricorythodes	104	12	73
LUMBRICINA			
Lumbricina	1		1
MEGALOPTERA			
Corydalus	2		
Nigronia serricornis	2	*	
NEOTAENIOGLOSSA			

Station: Strother Creek 2751_5.5			
Sample: 21069			
Elimia	166	37	3
ODONATA			
Argia		5	
Boyeria			2
Gomphidae	2		
Hagenius brevistylus		1	1
Macromia		1	1
Progomphus obscurus		*	
Stylogomphus sigmastylus		2	
PLECOPTERA			
Amphinemura	2		8
Leuctridae	7	17	
Perlesta			5
TRICHOPTERA			
Cernotina	3	2	3
Cheumatopsyche	18	*	7
Chimarra	7		1
Helicopsyche	20		
Hydroptila	4	1	6
Oecetis	5	1	2
Oxyethira	1	8	72
Pycnopsyche		2	3
Triaenodes			8
TRICLADIDA			
Planariidae	2	3	
TUBIFICIDA			
Branchiura sowerbyi		1	
Enchytraeidae		1	1
Tubificinae		2	
VENEROIDA			
Pisidiidae	1		

Station: Strother Creek 2751_3.3			
Sample: 21070			
Date March 22, 2021			
* - large rare			
ORDER	CS	NF	RM
"HYDRACARINA"			
Acarina	2	7	7

Station: Strother Creek 2751_3.3			
Sample: 21070			
AMPHIPODA			
Hyalella azteca		11	13
BRANCHIOBELLELLIDA			
Branchiobdellida			1
COLEOPTERA			
Dubiraphia	1	3	1
Dytiscidae		1	
Ectopria nervosa		1	1
Optioservus sandersoni	9	3	2
Paracymus		4	1
Psephenus herricki	10	4	1
Stenelmis	7	6	3
DECAPODA			
Faxonius hylas		2	2
Faxonius neglectus	1		
DIPTERA			
Ablabesmyia		1	
Antocha	5		
Ceratopogoninae		2	
Cladotanytarsus		2	
Clinocera	17	1	1
Corynoneura		3	2
Cricotopus trifascia	3		1
Cricotopus/Orthocladius	19	3	10
Ephydriidae		1	
Eukiefferiella	3		
Gonomyia	2		
Hemerodromia			2
Hexatoma		9	
Micropsectra			1
Microtendipes		3	
Natarsia		1	
Parametrioctenus	14	6	6
Paratanytarsus			3
Pentaneura	1		
Polypedilum aviceps	4	1	
Polypedilum flavum	5	1	
Procladius		1	
Prosimulium	10		6

Station: Strother Creek 2751_3.3			
Sample: 21070			
Psychoda		1	
Rheotanytarsus	4	1	4
Simulium	5		
Stempellinella	3	31	5
Tabanus		1	
Tanytarsus	28	29	8
Thienemanniella	1	1	3
Thienemannimyia grp	3	35	5
Tipula	*	*	
Tribelos		2	
Zavreliomyia		3	
EPHEMEROPTERA			
Acentrella	1		
Baetisca lacustris			1
Caenis latipennis	4	26	13
Ephemerella invaria	1		
Eurylophella bicolor	31	27	57
Isonychia bicolor	24		5
Leptophlebia		1	2
Stenacron	1	4	1
Stenonema bednariki	5		
Stenonema femoratum		3	1
Stenonema mediopunctatum	9		
Stenonema pulchellum			3
Teloganopsis deficiens	1		
LUMBRICINA			
Lumbricina	1	2	
MEGALOPTERA			
Corydalis	1	1	2
NEOTAENIOGLOSSA			
Elimia	31	5	18
ODONATA			
Argia	4	7	3
Calopteryx			1
Hagenius brevistylus			1
Stylogomphus sigmastylus	1	9	3
PLECOPTERA			
Amphinemura	6		4

Station: Strother Creek 2751_3.3			
Sample: 21070			
Leuctridae	52	40	18
Neoperla	1	1	
Perlesta			2
Prostoia			1
Pteronarcys pictetii			1
TRICHOPTERA			
Agapetus	14	2	
Cheumatopsyche	60	1	6
Chimarra	9		
Helicopsyche	15	4	14
Hydropsyche morosa grp	3		2
Mystacides		2	
Ochrotrichia	2	1	4
Oecetis		1	
Oxyethira		3	50
Plectrocnemia	1	1	
Polycentropus	1	7	5
Pycnopsyche			2
Setodes	1		
TRICLADIDA			
Planariidae	5	1	2
TUBIFICIDA			
Ilyodrilus templetoni		1	
Tubificinae		7	

Station: Strother Creek 2751_-0.1			
Sample: 21071			
Date March 22, 2021			
* - large rare			
ORDER	CS	NF	RM
"HYDRACARINA"			
Acarina	2	7	7
AMPHIPODA			
Hyalella azteca		11	13
BRANCHIOBELLELLIDA			
Branchiobdellida			1
COLEOPTERA			
Dubiraphia	1	3	1
Dytiscidae		1	
Ectopria nervosa		1	1

Station: Strother Creek 2751_-0.1 Sample: 21071			
Optioservus sandersoni	9	3	2
Paracymus		4	1
Psephenus herricki	10	4	1
Stenelmis	7	6	3
DECAPODA			
Faxonius hylas		2	2
Faxonius neglectus	1		
DIPTERA			
Ablabesmyia		1	
Antocha	5		
Ceratopogoninae		2	
Cladotanytarsus		2	
Clinocera	17	1	1
Corynoneura		3	2
Cricotopus trifascia	3		1
Cricotopus/Orthocladius	19	3	10
Ephydriidae		1	
Eukiefferiella	3		
Gonomyia	2		
Hemerodromia			2
Hexatoma		9	
Micropsectra			1
Microtendipes		3	
Natarsia		1	
Parametriocnemus	14	6	6
Paratanytarsus			3
Pentaneura	1		
Polypedilum aviceps	4	1	
Polypedilum flavum	5	1	
Procladius		1	
Prosimulium	10		6
Psychoda		1	
Rheotanytarsus	4	1	4
Simulium	5		
Stempellinella	3	31	5
Tabanus		1	
Tanytarsus	28	29	8
Thienemanniella	1	1	3
Thienemannimyia grp	3	35	5

Station: Strother Creek 2751_-0.1 Sample: 21071			
Tipula	*	*	
Tribelos		2	
Zavreliomyia		3	
EPHEMEROPTERA			
Acentrella	1		
Baetisca lacustris			1
Caenis latipennis	4	26	13
Ephemerella invaria	1		
Eurylophella bicolor	31	27	57
Isonychia bicolor	24		5
Leptophlebia		1	2
Stenacron	1	4	1
Stenonema bednariki	5		
Stenonema femoratum		3	1
Stenonema mediopunctatum	9		
Stenonema pulchellum			3
Teloganopsis deficiens	1		
LUMBRICINA			
Lumbricina	1	2	
MEGALOPTERA			
Corydalus	1	1	2
NEOTAENIOGLOSSA			
Elimia	31	5	18
ODONATA			
Argia	4	7	3
Calopteryx			1
Hagenius brevistylus			1
Stylogomphus sigmastylus	1	9	3
PLECOPTERA			
Amphinemura	6		4
Leuctridae	52	40	18
Neoperla	1	1	
Perlesta			2
Prostoia			1
Pteronarcys pictetii			1
TRICHOPTERA			
Agapetus	14	2	
Cheumatopsyche	60	1	6

Station: Strother Creek 2751_-0.1			
Sample: 21071			
Chimarra	9		
Helicopsyche	15	4	14
Hydropsyche morosa grp	3		2
Mystacides		2	
Ochrotrichia	2	1	4
Oecetis		1	
Oxyethira		3	50
Plectrocnemia	1	1	
Polycentropus	1	7	5
Pycnopsyche			2
Setodes	1		
TRICLADIDA			
Planariidae	5	1	2
TUBIFICIDA			
Ilyodrilus templetoni		1	
Tubificinae		7	
Oecetis	4	1	2
Oxyethira			36
Plectrocnemia	4	2	7
Polycentropus		1	1
Psychomyia	2		
Pycnopsyche	1	*	2
Triaenodes			2
TRICLADIDA			
Planariidae	6	1	1
TUBIFICIDA			
Branchiura sowerbyi		7	
Enchytraeidae			1
Limnodrilus hoffmeisteri		9	1
Tubificinae		22	
VENEROIDA			
Pisidiidae		1	